

ANALYSIS OF OPERATION OF SOUTH ENTRANCE STATION AT GRAND CANYON NATIONAL PARK

Prepared for Grand Canyon National Park

By

**Jonathan Upchurch, P.E., P.T.O.E., Ph.D.
National Park Transportation Scholar**

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DISCLAIMER

The contents of this report represent the findings and opinions of the author and not necessarily those of the National Park Service, Grand Canyon National Park, or the National Park Foundation.

EXECUTIVE SUMMARY

This comprehensive report presents information on the operation of the South Entrance Station at Grand Canyon National Park. Included are information on existing conditions and current operating characteristics, traffic volumes, capacity of the entrance station, queue lengths and waiting times, and strategies to facilitate the processing of vehicles.

The findings of this report will assist Grand Canyon National Park in the management of the South Entrance Station and in decision-making on future strategies to reduce congestion.

In a one year period 941,230 vehicles passed through the South Entrance during the hours that the Entrance Station was in operation.

During the “peak season” and other selected holiday periods it is not unusual for long waiting lines (one mile or more) to stack up and for visitors to encounter long waiting times to enter the Park.

The “peak season” begins in mid-March and visitation remains high (with the exception of the end of August) until mid-October. Apparent spikes in visitation are associated with the days surrounding Easter, Memorial Day, July 4th, Labor Day, Thanksgiving, and Christmas. The highest volume day in the past year was Sunday, July 3, 2005 when 4,775 vehicles were processed at the South Entrance Station.

The average time to process a vehicle is 39 seconds and the capacity of the South Entrance Station is in the range of 353 to 368 vehicles per hour under average conditions.

When the queue extends a mile or more, the total waiting time to the entrance station ranges from about 30 minutes at locations near the Park Boundary and the former Moqui Lodge, to the range of 37 to 42 minutes at locations near, and south of, the “1 MILE” sign. If a vehicle uses the Express Lane, its total waiting time is, on the average, about 8 minutes less than these values.

During a full year, it is estimated that 157 days experience at least one hour when demand exceeds capacity and that there are 515 hours per year during which demand exceeds capacity. These are the hours in which lines form and long queues develop.

Several strategies are already in use at the South Entrance Station to facilitate transactions. They are: the express lane, the use of roving Visitor Use Assistants, “off-line approvals” for credit cards, suspension of photo ID checks, and sale of entry permits at remote locations. Potential additional strategies include: increase the number of lanes, lengthen the express lane, automated lanes, increase the sales of entry permits at remote locations, discontinue passenger counts, improve information for visitors, and more extensive use of Highway Advisory Radio.

A discussion of Entrance Station improvements in the context of the Grand Canyon transportation plan is included.

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INTRODUCTION

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The findings of this report will assist Grand Canyon National Park in the management of the South Entrance Station and in decision-making on future strategies to reduce congestion.

EXISTING CONDITIONS

Grand Canyon National Park is one of the most heavily visited units in the National Park System. With 4,326,234 Recreational Visits in 2004, Grand Canyon ranked second among the 57 National Parks in number of visitors (Ref. 1).

The vast majority (95 percent) of visitors to Grand Canyon National Park arrive by vehicle. About 4.9 percent enter the Park via the Grand Canyon Railway (210,866 visitors in 2004) (Ref. 2) and a relatively small number of visits are Colorado River raft trips (about 37,000 visits annually) (Ref. 2).

The “South Rim” and the “North Rim” developed areas account for almost all of the Park’s visitation and the South Rim draws much larger numbers of visitors than the North Rim. The “North Rim” developed area is accessible by roadway at only one location, while the “South Rim” developed area is accessible at two locations – the South Entrance (by the community of Tusayan) and Desert View. Year 2003 Average Annual Daily Traffic (AADT) volumes (Ref. 3) at these three access points show that 75 percent of the traffic volume is at the South Entrance.

	<u>2003 AADT</u>	<u>percent of total</u>
North Rim	442	6
Desert View	1505	19
South Entrance	<u>5985</u>	<u>75</u>
Total	7932	100

Note: the AADT volumes are for two directions of traffic

Thus, very large volumes of traffic approach the South Entrance Station. Statistics provided by Park staff show that in a one year period 941,230 vehicles passed through the South Entrance during the hours that the Entrance Station was in operation.

During the summer season and other selected holiday periods it is not unusual for long waiting lines to stack up and for visitors to encounter long waiting times to enter the Park. These are the symptoms of demand (number of vehicles arriving in a period of time) exceeding the capacity of the entrance station (number of vehicles that can be processed in the same period of time).

On Sunday, May 26, 2002 (Memorial Day weekend) the line at the South Entrance Station stretched for 1.7 miles to the community of Tusayan (see photos). While this was one of the more extreme cases, Park staff state that on “almost any summer day and most holidays we experience long lines at the South Entrance” (Ref. 4).

**Four lanes open
at Grand
Canyon South
Rim Entrance
Station – May
26, 2002**



**Queue at Grand Canyon
South Rim – May 26, 2002**



**Queue 1 mile from Entrance Station
May 26, 2002**



**End of Queue at village of Tusayan, 1.7 miles from
Entrance Station – May 26, 2002**

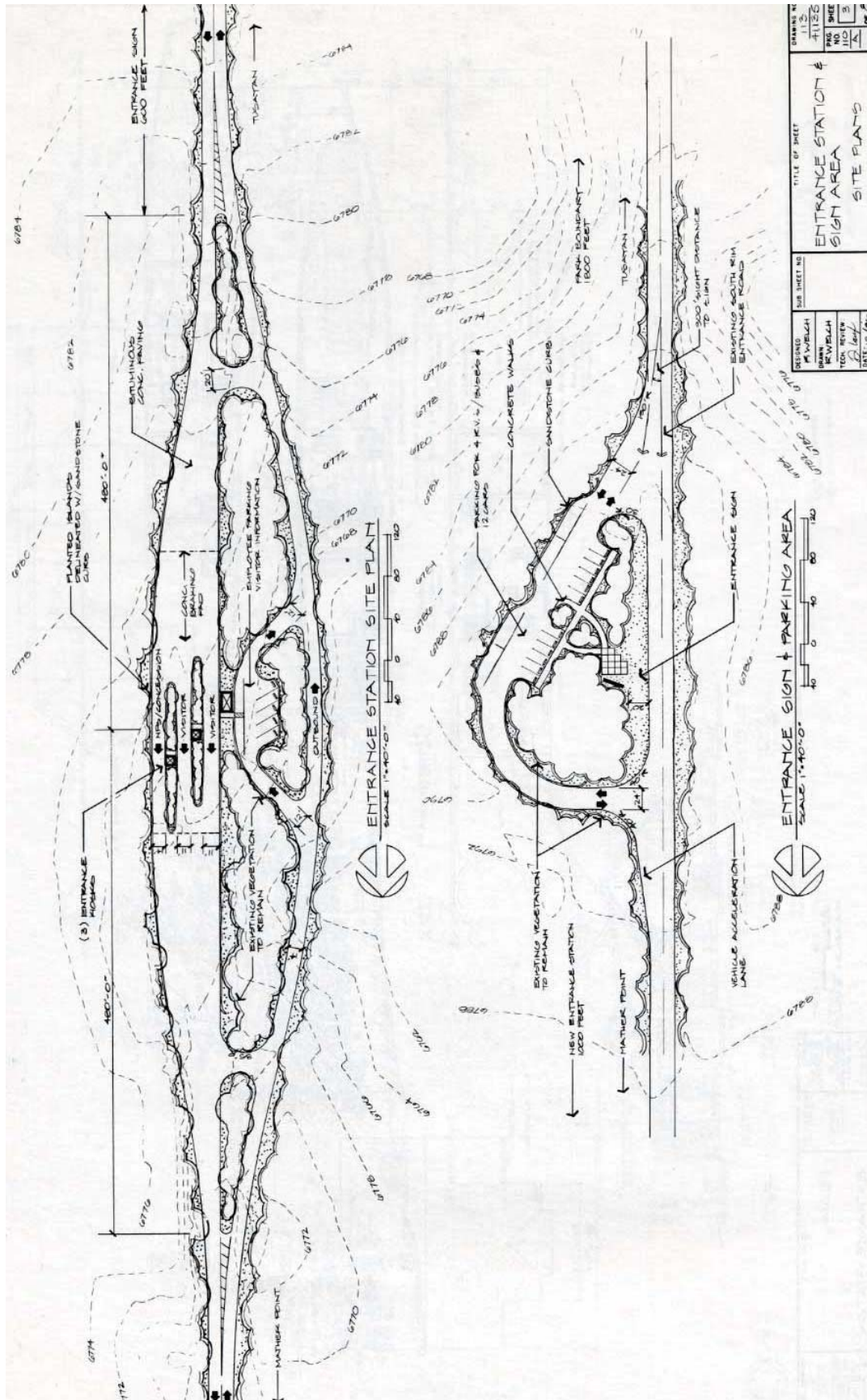
HISTORY OF PREVIOUS AND CURRENT ENTRANCE STATIONS

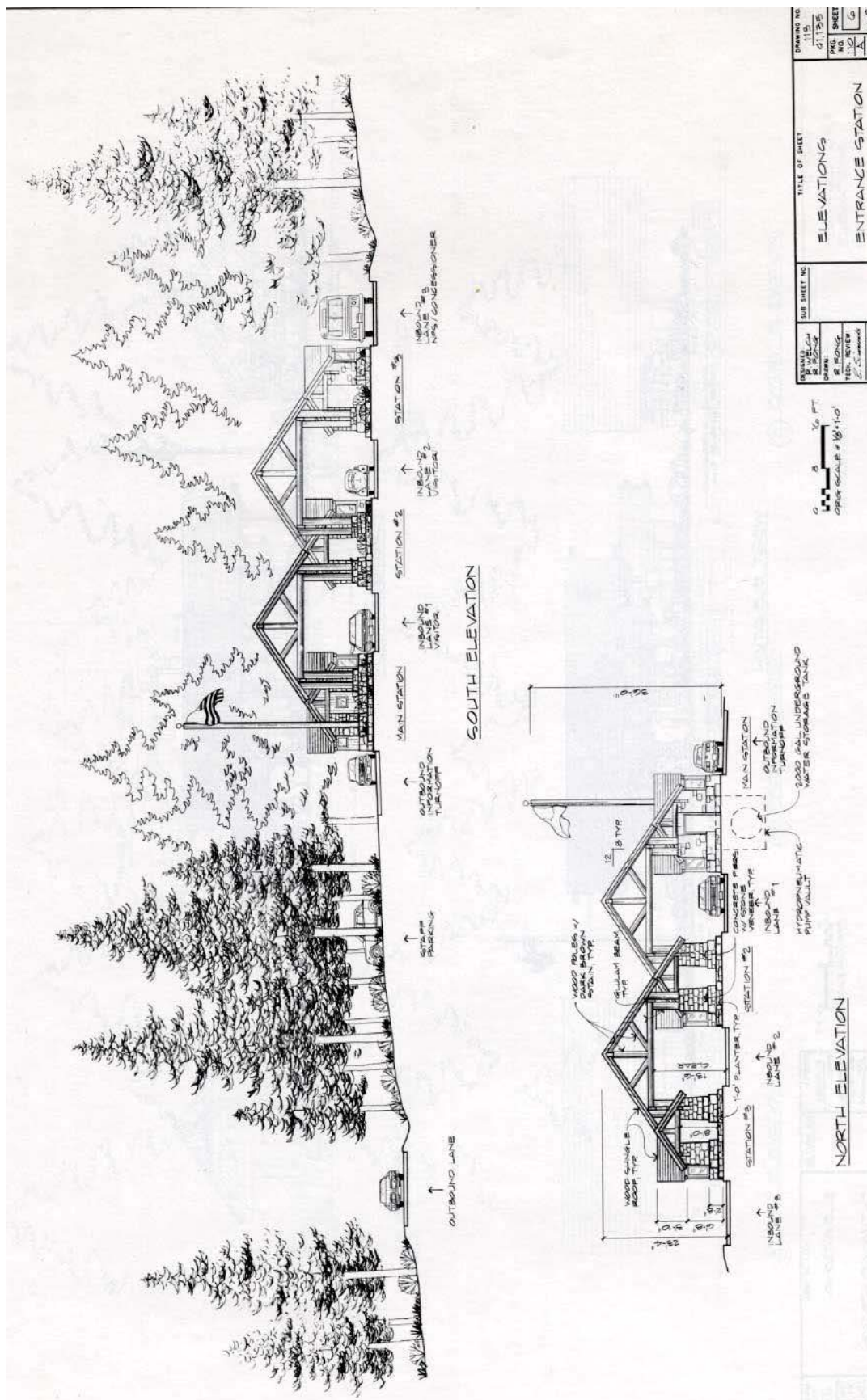
For a period of time that ended in the late 1980's, the South Entrance was served by a two-lane entrance station (Figure 1). As shown in the photo, one of the two lanes was apparently devoted to Park residents and employees and only one lane processed Park visitors. This was in an era when: visitation was lower; the fee structure was simpler than it is today; credit card purchases of entry permits were probably not utilized; and the community of Tusayan was less developed. Because Tusayan was not as developed, a greater percentage of Park visitors stayed within the Park, rather than traveling back and forth between the Park and Tusayan and generating re-entries to the Park.



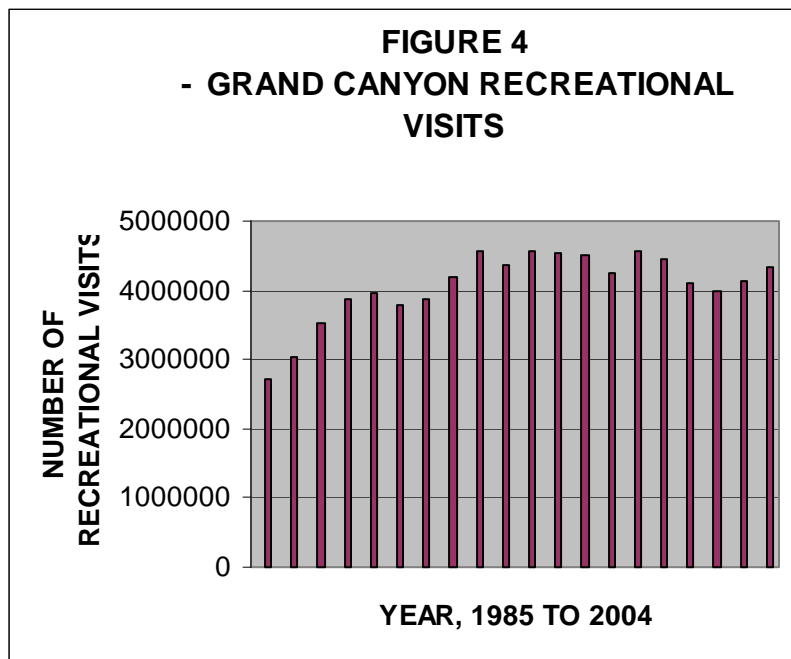
Figure 1 - South Entrance Station, 1986 (Ref. 5)

In the mid-1980's a new entrance station facility was planned and designed and it is believed it was constructed and opened to operation by the late 1980's. Figures 2 and 3 are plan drawings dated December, 1986 (Ref. 5). A close inspection of the drawings shows that the entrance station was designed for three lanes of inbound traffic. The west side of the entrance station provided a turnout at which visitors leaving the Park could drive up to a window to ask questions and seek information.





In 1986, when the new entrance station was being designed, the Park's annual visitation exceeded 3 million for the first time (Figure 4). A new facility, with greater capacity, was probably a great relief. Park visitation continued to grow rapidly, exceeding 4 million visitors per year for the first time in 1992 and exceeding 4.5 million per year four times in the latter 1990's. Due to the growth in visitation, three lanes apparently became inadequate. At some point in time the entrance station was modified to remove the outbound turnout and convert the west side window to serve a new, fourth, lane to serve inbound traffic. This lane now serves as the "express" lane.



Although Park's annual visitation has not achieved the 4.5 million level during the past five years, it has consistently exceeded 4 million and reached 4.33 million in 2004. Thus, there has continued to be high demand at the South Entrance Station. Park staff also observed that the implementation of the National Park Pass in 2001 resulted in a more complex fee structure that has contributed to the time required to serve customers. As a result, congestion at the South Entrance Station continues to be a common occurrence during peak season.

CURRENT OPERATING CHARACTERISTICS

Hours of operation vary with the season. Morning opening time is selected in order to catch the "sunrise crowd" who lodge in Tusayan and travel into the Park to catch the morning sunrise. Evening closing time is scheduled after sunset so that the "sunset crowd" will also be captured for fee collection. The hours of operation during the past year are shown below.

July 1, 2004 – September 18, 2004	5:00 a.m. to 9:00 p.m.
September 19, 2004 – October 16, 2004	5:30 a.m. to 7:30 p.m.
October 17, 2004 – March 5, 2005	6:00 a.m. to 6:00 p.m.

March 6, 2005 – April 2, 2005
April 3, 2005 – April 16, 2005
April 17, 2005 – September 10, 2005

6:00 a.m. to 7:00 p.m.
5:00 a.m. to 8:00 p.m.
5:00 a.m. to 9:00 p.m.

After the evening closing, vehicular traffic is free to pass through the entrance station without paying a fee.

Grand Canyon National Park uses custom-made fee collection software that is different from that used by other National Park Service units.

Although there are four lanes passing through the entrance station itself, most of the roadway from Tusayan (1.7 miles south of the entrance station) to the entrance station is a single northbound travel lane. In the vicinity of the intersection serving the Tusayan Ranger Station (0.89 mile south of the entrance station) there are deceleration and acceleration lanes which are sometimes used as a second lane when the queue extends that far upstream from the entrance station. If two lanes are used, vehicles must merge back into a single lane by the end of the acceleration lane.

Approximately 470 feet from the entrance station building the roadway begins to widen from a single lane to four lanes and all four lanes exist at a point about 380 feet from the entrance station (see photos) This allows the westernmost (or left) lane to serve as the “express” lane (the express lane is physically separated from the other three lanes). The three remaining lanes are contiguous and lane changing may occur between these lanes. Commercial vehicles (tour buses, for example) must use the easternmost (or right) lane. Other vehicles are allowed to use any of the three lanes, including the right lane.



“Express Lane”



Four Lane Approach to Entrance Station

The 380 foot distance was observed to be long enough to allow, on average, 18 vehicles to “stack” in each lane (from the beginning point - where the roadway first becomes four lanes wide – to the entrance station). Thus, about 72 vehicles “stack” in the four lane section.

The express lane may be used by any vehicle that has a prepaid permit or is otherwise not required to pay a fee for entry to the Park. These vehicles include holders of: a previously purchased National Parks Pass, National Parks Pass with Golden Eagle Hologram, Golden Age Passport, Grand Canyon National Park Annual Pass, or Seven-Day Entry Permit; a previously acquired Golden Access Passport; Park residents or employees; or Park business-related vehicles.

The express lane can process vehicles at a much faster rate than the other three lanes. Frequently the queue of stacked vehicles in the other three lanes extends far enough to block access to the express lane. The result is no supply of vehicles for the express lane and inefficient “dead time” for that lane. During busy periods a Visitor Use Assistant (VUA) will often “rove” the lines of waiting vehicles and perform “traffic control” by directing vehicles to various lanes. If the VUA observes that the express lane is blocked, or does not otherwise have a supply of prepaid permit vehicles, the VUA may direct “regular” users to that lane.

Signing and Marking

Four signs along the approach to the entrance station provide information on lane usage. The four signs, in their order of appearance, are shown in the photos. The third and fourth signs repeat the information shown on the first and second signs.

The first and third signs are a combination of word message and symbol that indicate four lanes approaching the entrance station and the word message that “Prepaid Permits Use Left Lane”. Yellow color coding is used on the word message and for the arrows on the left lane to reinforce the concept that it is the left lane that is to be used by prepaid permits.

The second and fourth signs state that “Prepaid Permits Only” are to “Use Left Lane”. The sign also lists most (but not all) of the classes of vehicles that may use the “express lane”. Golden Eagle, Golden Age, Golden Access, Re-Entry, Annual Pass, and Park Residents are specifically identified. One class of eligible vehicle that is not specifically identified is National Parks Pass. Yellow color coding is again used for the above wording.



Sign 1



Sign 2

A separate sign panel presents the message, “Commercial Vehicles Right Lane Only”. A fifth sign is located at the beginning of, and on the left side of, the express lane. The sign message is “Prepaid Permits” (see “Express Lane” photo on page 7).

At the beginning of the four lane wide approach to the entrance station, lane numbers appear on the pavement as pavement markings (see photo). Lane 1 is the left (west) lane (the express lane) and Lane 4 is the right (east) lane. A roving VUA may refer to the lane numbers when directing traffic to certain lanes.



Sign 3



Sign 4

QUANTITATIVE INFORMATION

The next several pages of this report present information on traffic volumes, transaction times, entrance station capacity, queue lengths, and waiting times. The value of this quantitative information is that it will: 1) assist in identifying the nature of the entrance station congestion problem; 2) aid in identifying strategies to alleviate the problem; 3) evaluate the potential effect of various strategies; and 4) aid in decision-making.

WHEN DO HIGH VOLUME DAYS OCCUR ?

Like many other National Parks, visitation at the Grand Canyon is seasonal. Inadequate capacity, long queues, and long waiting times become an issue on the higher volume days of the year.

Figure 5 presents information on the number of vehicles entering at the South Entrance Station (during the hours the Entrance Station was in operation) during a 12 month period. The data from September 1 through December 31 are for the year 2004. The data from January 1 through August 31 are for the year 2005. The numbers of vehicles entering the Park was obtained from the Park’s fee collection software.

The seasonal pattern at Grand Canyon is obvious. The “peak season” has very broad shoulders with visitation increasing substantially during the month of March and remaining high (with the exception of the end of August) until mid-October. Apparent spikes in visitation are associated with New Year’s, on the days surrounding Easter (March 27 in 2005), Memorial Day, July 4th, Labor Day, Thanksgiving, and Christmas. There is also a modest phenomenon of visitation being higher on Saturdays during some parts of the year. It is most obvious on Saturdays in September and early October (see Figure 5). The highest volume day was Sunday, July 3, 2005 when 4,775 vehicles were processed at the South Entrance Station. The days with higher volume

– those days with greater than about 3000 to 3500 vehicles – generally correspond with the Park staff’s anecdotal accounts of the days that have long queues and long waiting times.

For comparison purposes, Figure 6 presents information on the number of vehicles entering Arches National Park on each day in 2003. The highest number of vehicles (1394) entered Arches on a Saturday in May. Arches also has broad shoulders to its peak season. The weekend phenomenon is much more pronounced at Arches and is obvious from March through October.

As a second comparison, Figure 7 presents similar information for Mesa Verde National Park for 2004. At Mesa Verde, the highest number of vehicles (1211) entered the Park on Memorial Day weekend. The weekend phenomenon does not occur at Mesa Verde. In fact, the highest volume days during mid-summer are on Wednesdays. Compared to Grand Canyon and Arches, Mesa Verde has very narrow shoulders; i.e., a much shorter peak season.

In one sense, Grand Canyon National Park is fortunate that it’s peaking (both seasonally, and on weekends) is not as pronounced as Arches and Mesa Verde.

**FIGURE 5 -
NUMBER OF VEHICLES ENTERING GRAND CANYON SOUTH ENTRANCE STATION BY DAY**

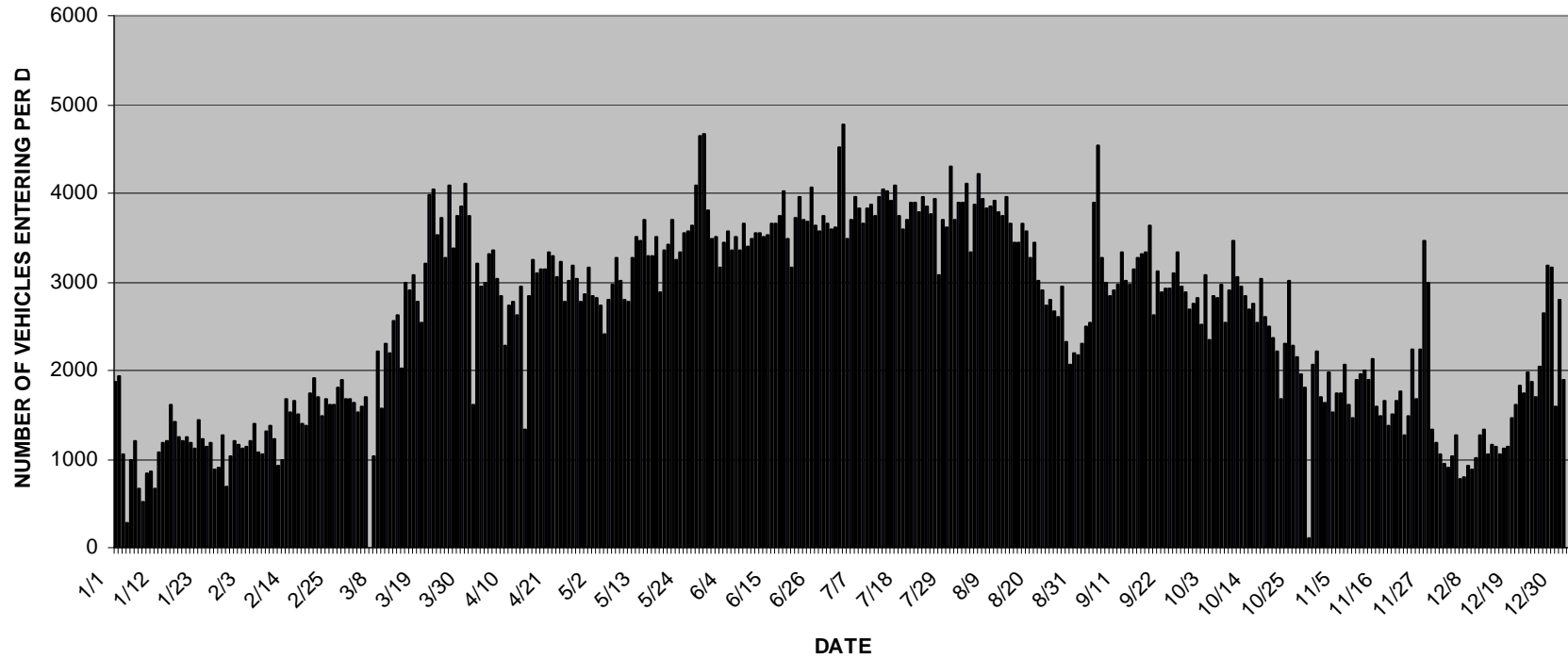


FIGURE 6 - NUMBER OF VEHICLES ENTERING ARCHES NATIONAL PARK BY DAY - 2003

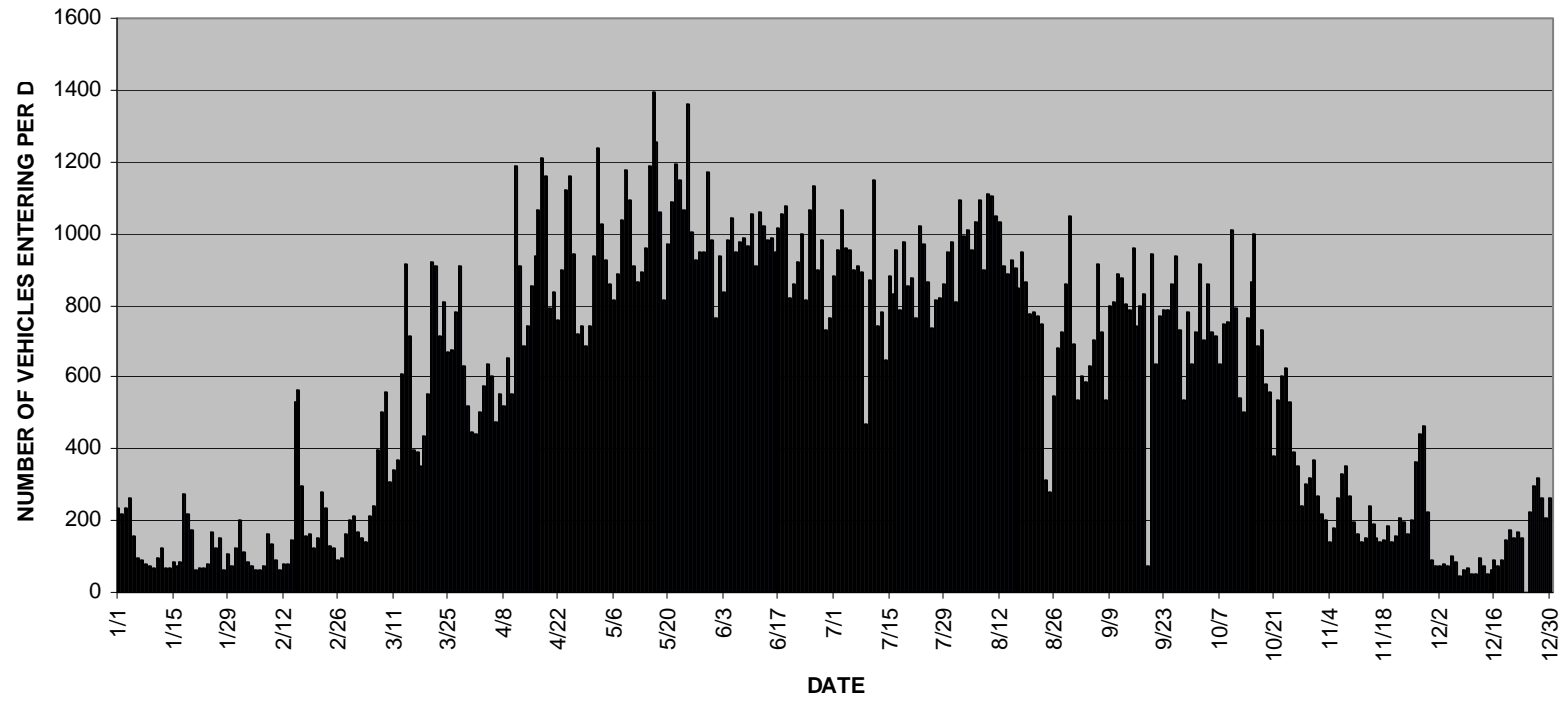


FIGURE 7 - NUMBER OF VEHICLES ENTERING MESA VERDE NATIONAL PARK BY DAY - 2004

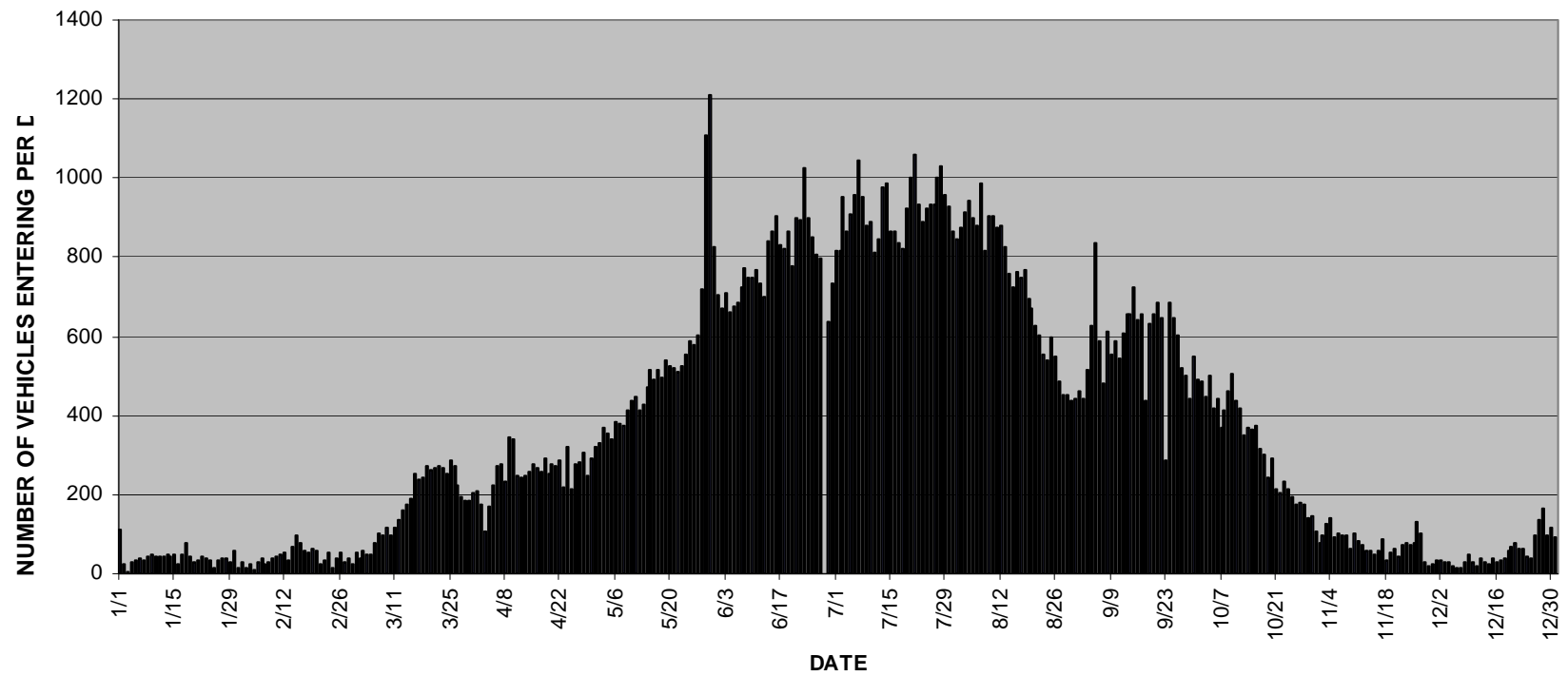


Figure 8 shows the *distribution* of the number of vehicles entering at the South Entrance Station by day. For example, there were 17 days on which 4000 or more vehicles entered and 154 days on which 3000 or more vehicles entered. Table 1 also summarizes the distribution.

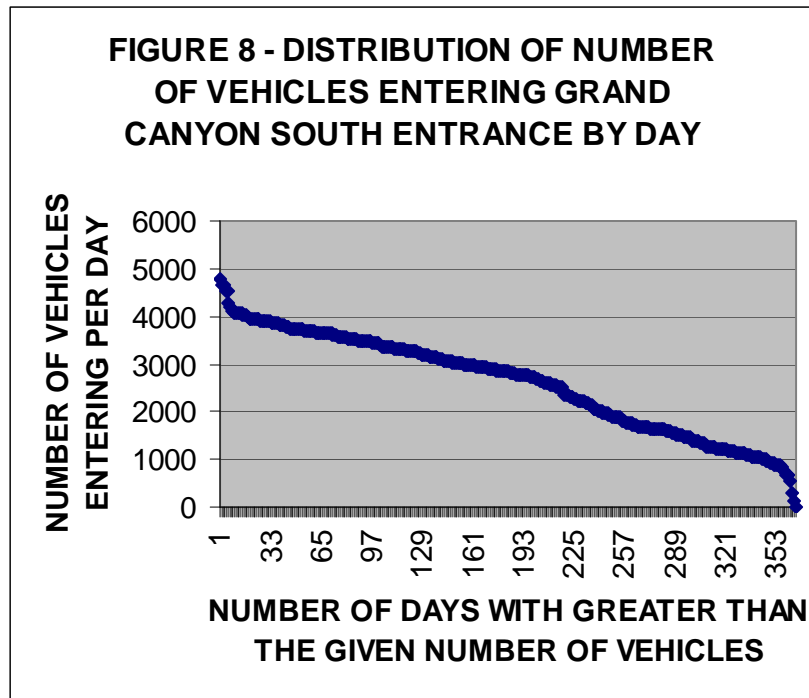


TABLE 1 - DISTRIBUTION OF ENTERING VEHICLES	
Highest day -- 4775 entering vehicles	
Number of days with 4500 or more entering vehicles	5
Number of days with 4000 or more entering vehicles	17
Number of days with 3800 or more entering vehicles	40
Number of days with 3600 or more entering vehicles	73
Number of days with 3400 or more entering vehicles	101
Number of days with 3200 or more entering vehicles	129
Number of days with 3000 or more entering vehicles	154
Number of days with 2500 or more entering vehicles	217
Number of days with 2000 or more entering vehicles	242
Number of days with 1500 or more entering vehicles	291
Number of days with 1000 or more entering vehicles	345

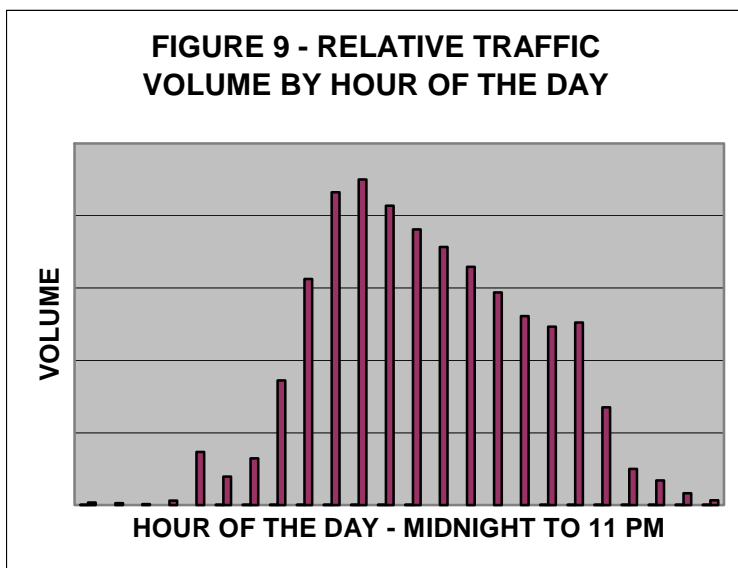
WHEN DO HIGH VOLUME HOURS OCCUR?

The National Park Service has inductive loop detectors and a traffic counter at the intersection of the South Entrance Road and Center Road. Inductive loops are present in each lane approaching the intersection. Traffic volume counts, by hour were obtained for northbound traffic for the time period from April 8, 2005 to September 30, 2005. There are no locations between the

entrance station and the detectors at which traffic turns on to or off of the Main Entrance Road. Based on a comparison, these Northbound traffic counts were found to be a reliable surrogate for the number of transactions at the entrance station. An advantage of using the traffic counts as a surrogate is that the data were readily available on an hour by hour and day by day basis for a period of almost six months.

Figure 9 presents the profile of traffic volume, hour by hour, for an average day in June, for northbound traffic. The bar chart begins with the hourly volume from 12:00 midnight to 12:59 a.m. on the left and ends with the hourly volume from 11:00 p.m. to 11:59 p.m. on the right.

Peak volume occurs between 10:00 and 11:00 a.m. A small peak occurs during the 4:00 a.m. hour, which likely is comprised of visitors wanting to watch sunrise over the Canyon and hikers desiring an early start, while temperatures are still cool. Traffic volume grows quickly from 6:00 a.m. until 10:00 a.m. Volume then gradually declines with a slight increase during the 6:00 p.m. hour. A steep decline in volume occurs from the 6:00 hour to the 8:00 hour.



The Park's fee collection staff report long lines at the entrance station during different time spans in different months. A review of the traffic volume data shows high volume hours that would coincide with long lines during the following time periods.

April and May	9:00 a.m. to 12:00 noon
Memorial Day weekend	9:00 a.m. to 6:00 p.m.
June	9:00 a.m. to 2:00 p.m.
July and early August	9:00 a.m. to 2:00 p.m., sometimes as late as 4:00 or 5:00
Labor Day weekend	9:00 a.m. to 5:00 p.m.

A further discussion of the time periods with long lines is presented in a subsequent section on Time Periods When Demand Exceeds Capacity.

TERMINOLOGY

In this report “service time” is defined as the length of time required for the Visitor Use Assistant to process a customer at an entrance station. Service time begins when the vehicle comes to a stop at the entrance booth (arrival time). Service time ends when the vehicle begins to pull away from the entrance booth (departure time). Service time is measured in minutes and seconds.

“Move-up time” occurs between the departure time of one vehicle and the arrival time of the following vehicle when there is a continuous supply of vehicles waiting to be served.

“Interval between arrivals”, as used in this report, is the sum of service time and move-up time.

“Capacity” for an entrance station is defined as the number of vehicles per hour that can be processed in a lane (or lanes) at an entrance station. Capacity is measured in vehicles per hour, but the rate can also apply to a shorter period of time. If capacity is 120 vehicles per hour, this means that 20 vehicles per ten minute period can be processed.

FACTORS AFFECTING SERVICE TIMES AND CAPACITY

Service times and, in turn, capacity are influenced by many different factors. The factors include the following.

1. The type of entry into the Park. A visitor who presents a previously purchased pass can be processed quickly. In contrast, a visitor who wants to purchase a National Parks Pass or an entry permit with a credit card requires much greater time. A more complete list of different types of entry into a Park is presented later in this report.
2. The mix of transactions. The proportion of visitors who hold a previously purchased pass versus those who do not will significantly affect average capacity. If all visitors hold a previously purchased pass, a large number of vehicles per hour can be processed (high capacity). If all visitors must purchase an entry permit, a much smaller number of vehicles per hour can be processed (low capacity). For example, Zion National Park (one of the first Parks on the itinerary of many visitors touring the Grand Circle) sells a high number of National Parks Passes.
3. How well informed is the visitor about the various payment options for entering the Park? There are many options, and some options apply only to certain groups of individuals, such as the Golden Age Passport. The information displayed on signs approaching the entrance station may not display all of the choices. The visitor may need to ask questions about their choices.
4. Whether or not staff are deployed to “work the line” of vehicles to provide information and answer questions before the customer arrives at the booth.
5. The type of fee collection software and equipment and its reliability.

6. The amount of printed information and safety advisories given to the visitor. Some Parks must warn visitors of safe behavior around wildlife or roadway conditions. Parks with scheduled activities, such as the ticketed tours to Mesa Verde Cliff Dwellings, must provide information. As another example, Petrified Forest National Park asks each inbound visitor, “Do you have any rocks or petrified wood in your vehicle?” Glacier National Park measures the length of vehicles to ensure that they do not exceed the length limit for Going to the Sun Road.
7. The number of questions asked by the visitor. The variety of questions is broad, including questions about camping, activities in the Park, concession services, etc.
8. Whether or not a Visitor Center exists outside of the Park entrance (such as at Grand Teton National Park at Moose, Acadia National Park, and White Sands National Monument) and whether the visitor has stopped there. Visitors who have stopped at a Visitor Center are less likely to have questions to ask at the entrance station.
9. The proximity of a Visitor Center to the Park Entrance. If vehicle queues are long and a Visitor Center is nearby (just inside the Park entrance) the Visitor Use Assistant can encourage a visitor to stop at the Visitor Center to ask their questions, thus reducing the service time.
10. The length of the queue. A long queue may result in more rapid processing by the Visitor Use Assistant while the lack of any queue may result in more leisurely processing, extended conversation, and inviting the visitor to ask more questions than if the queue is long.
11. Service time will vary among Visitor Use Assistants, depending upon their length of experience as a VUA and their “style” of serving the visitor.

OBSERVED SERVICE TIMES

Data on service times were collected at the South Entrance Station on Saturday, Sunday, and Monday, September 3, 4 and 5, 2005. Data were collected for a total of almost nine hours over the course of the three days. For the purpose of fee collection operations, the four entrance station lanes are referred to (from west to east) as: Express Lane, Lane A, Lane B, and Lane C. Between two and two and one-half hours of data were collected from each lane.

The times of arrival and departure (hours:minutes:seconds) were recorded on a laptop computer, along with the type of transaction. The type of transaction was later confirmed with a time-stamped record produced by the fee collection system. Over 600 usable transactions were recorded.

At Grand Canyon, like most Parks, there are many different payment choices for entering the Park. In fact, only some of the choices are posted on the sign approaching the entrance station (see photo). A description of the choices at Grand Canyon is shown in Table 2. As indicated in Table 2, the most common payment choices during the nine hours of data collection were purchase of a Seven Day Re-Entry permit with cash (272 such transactions during the data collection period), presentation of a previously purchased National Parks Pass (75 transactions), and re-entry on a Seven Day Re-Entry permit (referred to in Table 2 as “RE-ENTRY SINGLE VISIT”).



Fees Posted on Sign at Entrance Station

Average service times for each type of transaction are also presented in Table 2. It is emphasized that service time varies from vehicle to vehicle; the values shown in Table 2 are simply average values. Some observations about average service times include the following.

1. There are differences in service time for payment by cash compared to payment by credit card. If a Seven Day Re-Entry permit is being purchased, the service time is significantly longer for a credit card purchase (51 seconds) than for a cash purchase (34 seconds).
2. Purchase of a National Parks Pass is actually faster by credit card (1 minute, 38 seconds) than by cash (1 minute, 55 seconds). It should be noted that in July, 2005 Grand Canyon National Park changed from “on-line approvals” to “off-line approvals” for credit card transactions. It is believed that this considerably reduced the transaction time for credit card purchases.
3. Purchase of some types of pass (Golden Age Passport, or National Parks Pass), even when paid by cash, takes considerably longer than a Seven Day Re-Entry permit. Each of these types of passes must be signed at point of purchase.
4. Re-entry by vehicles that previously purchased a Seven Day Re-Entry permit within the past 7 days is exceptionally fast – only 8 seconds.
5. Entry by presentation of a previously purchased pass results in a short service time (Grand Canyon Annual Park Pass – 21 seconds, Golden Eagle – 32 seconds, National Parks Pass – 24 seconds, Golden Age Passport – 26 seconds, Golden Access Passport – 34 seconds). The service time is longer than re-entry on a Seven Day Re-Entry permit because the identity of the passholder is often checked. In addition, each National Parks Pass is swiped in a cardreader to gather use statistics.
6. Some classes of users have very short service times (Re-entry Local – 3 seconds, Re-entry Business – 3 seconds, Re-entry Misc – 5 seconds).

TABLE 2 - TYPES OF TRANSACTIONS AND AVERAGE SERVICE TIMES

NOTE: This table presents Item ID and Receipt Alias **only for** those transaction types that represent a vehicle being processed

ITEM ID (A code used by the fee collection system)	RECEIPT ALIAS (As used by fee collection system)	EXPLANATION OF TYPE OF TRANSACTION	ENTRANCE FEE (per vehicle unless otherwise noted)	PAYMENT TYPE *	AVERAGE SERVICE TIME (MM:SS)	SAMPLE SIZE FOR AVERAGE SERVICE TIME	MOVE-UP TIME (MM:SS)	INTERVAL BETWEEN ARRIVALS (MM:SS)
PURCHASES								
00-704	GRCA PARK PASS	An annual pass for the calendar year for Grand Canyon National Park only	\$40	Cash		ND		
				Credit		ND		
05-707	HOLOGRAM	Purchase of Golden Eagle hologram for placement on National Parks Pass. This transaction may or may not occur at the same time that a National Parks Pass is purchased.	\$15	Cash		ND		
				Credit		ND		
10-624	National Parks Pass	National Parks Pass. Provides the holder and accompanying passengers entry to all NPS units for a 12-month period.	\$50	Cash	1:55	15	0:07	2:02
				Credit	1:38	12	0:07	1:45
15-709	SEVEN DAY RE-ENTRY	Entry fee for a vehicle. Provides 7-day admission to Park.	\$20	Cash	0:34	272	0:07	0:41
				Credit	0:51	33	0:07	0:58
20-709	INDIVIDUAL	Entry fee for a pedestrian, bicyclist, or motorcyclist	\$10 / person	Cash	0:26	5	0:07	0:33
				Credit	1:22	1	0:07	1:29
26-709	TRANSIT	This category represents (the number of) commercial vehicles offering point-to-point transportation service (like a taxi) without any "tour" of the Park or stops en-route. Those passengers required to pay an entry fee pay \$6 per person (Item ID 27-709, Receipt Alias "TRANSIT PAY"). Those passengers not required to pay are Item ID 25-709, Receipt Alias "# ON FREE TRANSIT". These vehicles pay the entry fees via cash or credit card and occasionally via a pre-authorized debit.	\$6 / person	Cash	2:05	1	0:07	2:12
				Credit	1:55	1	0:07	2:02
31-711	SHUTTLE	This category represents (the number of) shuttles. A "shuttle" is a commercial passenger carrying vehicle: a) with 25 or fewer seats (originating at any distance), or b) with 26 or more seats and originating within 100 miles of the Park entrance, and, in addition to a) or b), does not qualify in the TRANSIT category. Those passengers required to pay an entry fee pay \$8 per person (Item ID 32-711, Receipt Alias "SHUTTLE PAY"). Those passengers not required to pay are Item ID 30-711, Receipt Alias "# ON FREE SHUTTLE". These shuttles vehicles usually pay via pre-authorized debit, but occasionally pay via credit card.	\$8 / person	Pre-authorized Debit	1:39	10	0:07	1:46
				Credit	4:06	1	0:07	4:13

TABLE 2 (CONTINUED) - TYPES OF TRANSACTIONS AND AVERAGE SERVICE TIMES

ITEM ID (A code used by the fee collection system)	RECEIPT ALIAS (As used by fee collection system)	EXPLANATION OF TYPE OF TRANSACTION	ENTRANCE FEE (per vehicle unless otherwise noted)	PAYMENT TYPE *	AVERAGE SERVICE TIME (MM:SS)	SAMPLE SIZE FOR AVERAGE SERVICE TIME	MOVE-UP TIME (MM:SS)	INTERVAL BETWEEN ARRIVALS (MM:SS)
PURCHASES (CONTINUED)								
36-711	COMMERCIAL PAY	This category represents (the number of) motorcoaches with 26 or more seats <u>and</u> that originate more than 100 miles from the Park entrance. A flat rate of \$300 per vehicle applies, regardless of how many passengers are on board. These commerical vehicles pay via a pre-authorized debit.	\$300 / bus	Pre-authorized Debit	1:25	3	0:07	1:32
40-713	GOLDEN AGE PASS	Golden Age Passport. Provides the holder lifetime entry to all NPS units for a one-time fee of \$10. Holder must be U.S. citizens age 62 or older.	\$10	Cash	1:33	13	0:07	1:40
				Credit	1:23	1	0:07	1:30
		Golden Access Passport. Issued free of charge to those individuals who have a qualifying disability.	No charge		2:17	1	0:07	2:24
ENTRY ON A PREVIOUSLY ACQUIRED CREDENTIAL								
02-704	RE-ENTRY GRCA PARK P	Entry of a holder of the Grand Canyon National Park Annual Pass	\$0		0:21	2	0:07	0:28
07-707	RE-ENTRY GOLDEN EAGLE	Entry of a holder of a Golden Eagle	\$0		0:32	7	0:07	0:39
12-624	RE-ENTRY NATIONAL PP	Entry of a holder of a National Parks Pass	\$0		0:24	75	0:07	0:31
17-709	RE-ENTRY SINGLE VISIT	Re-entry of a vehicle that previously purchased a Seven-day Permit within the past 7 days	\$0		0:08	74	0:07	0:15
42-713	RE-ENTRY GOLDEN AGE	Entry of a holder of a Golden Age Passport	\$0		0:26	31	0:07	0:33
90	RE-ENTRY G. ACCESS	Entry of a holder of a Golden Access Passport	\$0		0:34	2	0:07	0:41
95	RE-ENTRY LOCAL	Entry by a Park resident or by native American who lives on lands adjacent to the Park	\$0		0:03	40	0:07	0:10
96	RE-ENTRY BUSINESS	Entry by a commercial business with an establishment within the Park, vendors serving the Park, UPS, etc.	\$0		0:03	9	0:07	0:10
97	RE-ENTRY MISC	Other vehicles that qualify for no fee, official vehicles	\$0		0:05	1	0:07	0:12
OTHER TYPES OF TRANSACTIONS (not coded in fee collection system)								
		The Park Service will provide a new, plastic, Golden Age Passport in exchange for an old carboard Passport	\$0		1:30	6	0:07	1:37
		The Park Service will provide a new, plastic, Golden Access Passport in exchange for an old carboard Passport	\$0					
ND = No Data for this type of transaction								

* "Cash" represents payment in cash, by traveler's check, or by personal check.

"Credit" represents payment by credit card

CAPACITY OF SOUTH ENTRANCE STATION

To determine capacity of an entrance station lane, the “move-up time” between vehicles must also be considered. “Move-up time” occurs between the departure time of one vehicle and the arrival time of the following vehicle when there is a continuous supply of vehicles waiting to be served. The average move-up time between vehicles was observed to be 7 seconds. Adding the average service time plus the move-up time yields the interval between arrivals shown in Table 1. The average move-up time between vehicles at Grand Canyon (7 seconds) is the same as the average move-up time observed at Arches National Park in March, 2005.

For a given Park, service times, move-up times, and the mix of transaction types can be used to generate an hourly value for capacity for average conditions. For example, for Grand Canyon South Entrance Station, the average time to process a vehicle can be computed as shown in Table 3.

Table 3 simply calculates a weighted average of the times associated with each type of transaction. The number of transactions shown in Table 3 represents the proportion of each transaction type at the South Entrance Station over a one year period (July 1, 2004 through June 30, 2005). The average time for all vehicles is 37 seconds. This includes both service time and move-up time.

As there are 3600 seconds in an hour, an average time per vehicle of 37 seconds means that $3600 / 37 = 97$ vehicles per hour can be processed. Thus, the capacity of one entrance lane would be 97 vehicles per hour under average conditions. This capacity is slightly overstated because it does not consider that time is consumed in shift changes, software system crashes and rebooting time.

The mix of transaction types does affect capacity and the mix does vary from day to day during the year. Data from the fee collection system show that a high volume holiday weekend in summer has a different mix from a high volume mid-week day in summer.

The above example relied on the proportion of transaction types over a one year period. In that example, 36.5 percent of the vehicles were purchasing a Seven-Day Re-entry Permit and 16.2 percent of the vehicles were Re-entry Local. How does that compare with a day that has a high volume and on which the ability to process vehicles would be critical? September 3, 2005 – a holiday weekend Saturday – had a very different mix of transaction types that included 50.0 percent of the vehicles purchasing a Seven-Day Re-entry permit and only 9.9 percent of the vehicles as Re-entry Local. A calculation of the average time for all vehicles on September 3 yielded a result of 42 seconds and a lesser capacity of 86 vehicles per hour per lane.

It is also of interest to determine the capacity of the Express Lane – which can be used only for certain transactions that have short transaction times – and the regular lanes. For this comparison, it was assumed that the Express Lane would be used solely by those vehicles that are usually eligible to use that lane and that the transactions would be in proportion to their mix

for the year as a whole. A calculation yielded an average time of 22 seconds per vehicle and a capacity of 164 vehicles per hour per lane.

For the regular lanes, it was assumed that the lane would be used by only those vehicles that are not eligible to use the Express Lane and that the transactions would be in proportion to their mix for the year as a whole. This calculation produced an average time of 57 seconds per vehicle and a capacity of 63 vehicles per hour per lane.

The above values for capacity per lane suggest that the four-lane entrance station at the South Entrance should be able to process in the range of 353 to 368 vehicles per hour under average conditions. Are these estimates reasonable? The answer is, yes. Data for September 3, 4 and 5 show that the actual number of vehicles processed per hour, when there was a continuous supply of vehicles, was about 346 vehicles per hour for the four lanes combined.

A few observations about capacity are worth noting.

First, a small number of transaction types account for a large proportion of all vehicles entering the Park. Based on entries for a 12 month period, one type of transaction accounts for over one-third of the entries, two types of transactions account for over one-half of the entries, and three types of transactions account for over two-thirds of the entries. Any improvements to entrance station operation should focus on improvements to those transaction types that account for the larger numbers of vehicles entering the Park.

Second, Re-Entry Local accounts for a very large number of the vehicles (16.2 percent) entering the Park. This group is comprised of Park residents and native Americans who live on lands adjacent to the Park and they are not required to pay an entry fee. Even though the processing time for these vehicles is short, the large number of vehicles mean that they absorb entrance station capacity.

Third, the number of commercial passenger-carrying vehicles entering the Park is significant. The transaction types of Transit, Shuttle, and Commercial accounted for 23,433 entries in a 12-month period. (See Table 2 for explanations of these transaction types.) Transit and Shuttle transaction types are charged on a per person basis, making fee collection more complex and time consuming. In addition, Shuttle and Commercial vehicles usually pay via a pre-authorized debit system that requires an exchange of paperwork between the vehicle driver and the VUA. This also increases the processing time, even though drivers are required to complete the paperwork before arriving at the entrance station.

TABLE 3 - AVERAGE TIME TO PROCESS A VEHICLE

ITEM ID (A code used by the fee collection system)	RECEIPT ALIAS (As used by fee collection system)	PAYMENT TYPE	INTERVAL BETWEEN ARRIVALS (MM:SS)	NUMBER OF TRANSACTIONS IN A GIVEN TIME PERIOD - SOUTH ENTRANCE *	INTERVAL BETWEEN ARRIVALS X NUMBER OF TRANSACTIONS
PURCHASES					
00-704	GRCA PARK PASS	Cash/Credit		0	0:00
05-707	HOLOGRAM	Cash/Credit		0	0:00
10-624	National Parks Pass	Cash	2:02	13	26:26
		Credit	1:45	20	35:00
15-709	SEVEN DAY RE-ENTRY	Cash	0:41	271	3:05:11
		Credit	0:58	94	1:30:52
20-709	INDIVIDUAL	Cash	0:33	7	3:51
		Credit	1:29	3	4:27
26-709	TRANSIT	Cash	2:12	1	2:12
		Credit	2:02	1	2:02
31-711	SHUTTLE	Pre-authorized Debit	1:46	11	19:26
		Credit	4:13	3	12:39
36-711	COMMERCIAL PAY	Pre-authorized Debit	1:32	10	15:20
40-713	GOLDEN AGE PASS	Cash	1:40	28	46:40
		Credit	1:30	3	4:30
	Golden Access Passport		2:24	0	0:00
ENTRY ON A PREVIOUSLY ACQUIRED CREDENTIAL					
02-704	RE-ENTRY GRCA PARK P		0:28	1	0:28
07-707	RE-ENTRY GOLDEN EAGLE		0:39	4	2:36
12-624	RE-ENTRY NATIONAL PP		0:31	118	1:00:58
17-709	RE-ENTRY SINGLE VISIT		0:15	136	34:00
42-713	RE-ENTRY GOLDEN AGE		0:33	53	29:09
90	RE-ENTRY G. ACCESS		0:41	11	7:31
95	RE-ENTRY LOCAL		0:10	162	27:00
96	RE-ENTRY BUSINESS		0:10	42	7:00
97	RE-ENTRY MISC		0:12	8	1:36
				TOTAL TRANSACTIONS = 1000	TOTAL TIME = 38592 seconds
				AVERAGE TIME TO PROCESS A VEHICLE = 37 SECONDS	
				CAPACITY = 97 VEHICLES PER HOUR PER LANE	

COMPARISON OF THREE PARKS

It is of interest to compare the interval between arrivals at the South Entrance Station with similar data that has been collected at other Parks – Arches and Yellowstone.

The same data collection procedures were used at Arches National Park in March, 2005. The fee schedules at Arches and Grand Canyon are different, so it is not possible to compare times for all the categories of fees that exist at the Grand Canyon. Most of the major fee categories, however, are the same.

Table 4 presents comparative data. For example, the interval between arrivals for re-entry on a Seven Day Re-Entry permit (listed as “RE-ENTRY SINGLE VISIT”) was 13 seconds at Arches compared to 15 seconds at Grand Canyon. As a second example, the interval between arrivals for purchasing a Seven-Day Re-Entry permit with cash at Arches was 37 seconds and 41 seconds at Grand Canyon.

Some types of transactions at Grand Canyon were processed faster than at Arches. This was true for credit card purchases of the National Parks Pass and Seven-Day Re-entry permits (see highlighted cells in Table 4). Credit card purchase of a Seven-Day Re-entry was 1 minute, 51 seconds at Arches, but only 58 seconds at Grand Canyon. A National Parks Pass, purchased with a credit card, took 1 minute, 54 seconds at Arches and a slightly shorter 1 minute, 45 seconds at Grand Canyon. The faster processing at Grand Canyon is likely due to the use of “off-line approvals” for credit cards at Grand Canyon, while Arches continues to use “on-line approvals”.

Other types of transactions were processed faster at Arches than at Grand Canyon. These include cash purchase of a National Parks Pass and re-entries on the National Parks Pass, Golden Age Passport, and Golden Access Passport (see highlighted cells in Table 4).

In 2003 data on interval between arrivals was collected at the North Entrance to Yellowstone National Park (Ref. 7). While the Yellowstone data was not subdivided into as many fee categories, some comparisons can still be made.

1. The interval between arrivals for vehicles re-entering the Park on a Seven-day Re-entry permit was 16 seconds at Yellowstone compared to 13 seconds at Arches and 15 seconds at Grand Canyon.
2. For those visitors who already held some form of pass (National Parks Pass, Golden Age Passport, Golden Access Passport) the interval between arrivals at Yellowstone was 24 seconds. At Arches the weighted average interval between arrivals for these three passes was 23 seconds and at Grand Canyon it was 32 seconds.
3. At Yellowstone the data for all types of purchases was lumped together. This included purchases of National Parks Passes, Golden Age Passports, Annual Area Permits for Yellowstone and Grand Teton, and Seven-Day Re-entry permits. At Yellowstone the

average interval between arrivals was 44 seconds. At Arches the weighted average for these types of purchases was 41 seconds and at Grand Canyon it was 58 seconds.

TABLE 4 - COMPARISON OF PROCESSING TIMES AT THREE PARKS							
ITEM ID (A code used by the fee collection system)	RECEIPT ALIAS (As used by fee collection system)	PAYMENT TYPE *	GRAND CANYON		ARCHES		YELLOWSTONE
			INTERVAL BETWEEN ARRIVALS (MM:SS)	SAMPLE SIZE FOR AVERAGE SERVICE TIME	INTERVAL BETWEEN ARRIVALS (MM:SS)	SAMPLE SIZE FOR AVERAGE SERVICE TIME	INTERVAL BETWEEN ARRIVALS (MM:SS)
PURCHASES							
10-624	National Parks Pass	Cash	2:02	15	1:06	8	
		Credit	1:45	12	1:54	10	
15-709	SEVEN DAY RE-ENTRY	Cash	0:41	272	0:37	152	
		Credit	0:58	33	1:51	10	
20-709	INDIVIDUAL	Cash	0:33	5	0:39	1	
		Credit	1:29	1			
40-713	GOLDEN AGE PASS	Cash	1:40	13	1:56	2	
		Credit	1:30	1			
ENTRY ON A PREVIOUSLY ACQUIRED CREDENTIAL							
17-709	RE-ENTRY SINGLE VISIT		0:15	74	0:13	43	0:16
12-624	RE-ENTRY NATIONAL PP		0:31	75	0:23	101	0:24
42-713	RE-ENTRY GOLDEN AGE		0:33	31	0:25	31	
90	RE-ENTRY G. ACCESS		0:41	2	0:22	10	
95	RE-ENTRY LOCAL		0:10	40	0:14	5	
96	RE-ENTRY BUSINESS		0:10	9			
97	RE-ENTRY MISC		0:12	1			
* "Cash" represents payment in cash, by traveler's check, or by personal check.							

A comparison can also be made of the average time to process a vehicle and capacity. At the South Entrance the average time to process a vehicle is 37 seconds under average conditions and this translates to a capacity of 97 vehicles per hour per lane under average conditions. At Arches National Park, the average processing time is 32 seconds, resulting in a capacity of 112 vehicles per hour per lane.

The lower capacity at the South Entrance Station should not be interpreted as meaning that the Grand Canyon Visitor Use Assistants are less efficient than those at Arches National Park. As described in the section on Factors Affecting Service Time and Capacity, there are numerous factors affecting service time.

Grand Canyon is a more complex Park than is Arches and this may result in more visitor questions. Unlike Arches, the South Entrance Station does not have a visitor center immediately inside the entrance to which visitors can be referred if they have numerous questions. Commercial buses, shuttles and transit are much more numerous at the Grand Canyon and these are transaction classes with long processing times. Arches has a much higher percentage of its entries that are re-entries on a National Parks Pass. At the South Entrance Station 11.78 percent

of the annual entries are National Parks Pass re-entries; on one high volume day at Arches, they were 26.2 percent of all transactions. This is a transaction type with a short processing time. These are some of the reasons that processing times at the South Entrance are longer than at Arches National Park.

QUEUE LENGTHS AND WAITING TIMES

Queue lengths and waiting times will vary from day to day and hour to hour. The length of queue will depend primarily on the arrival rate of vehicles compared to the capacity (or discharge rate) of the entrance station. When vehicles arrive at a faster rate than they can be processed at the entrance station, the queue will grow. When vehicles arrive at a slower rate than they can be processed, the queue will diminish. If the arrival rate exceeds the entrance station capacity for a prolonged period of time, the queue will exist for a long period.

Very generally speaking, whether queues will develop on any given day is related to the daily volume of traffic approaching the entrance station. Thus, daily volume information, as shown in Figure 5 can be used as a general predictor of the potential for queues developing. A second factor is also very instrumental in whether queues form. That factor is the magnitude of “peaking” during the day. If the daily traffic volume arrives at a uniform rate throughout the day, vehicles may pass through the entrance station with very little delay. This is because the rate at which the vehicles arrive is less than the entrance station capacity. On the other hand, if peaking occurs (for example, most of the daily traffic arriving between 10:00 a.m. and 2:00 p.m.), the arrival rate during the peak may exceed the capacity of the entrance station and queues will form and grow. The more pronounced the peaking of traffic during the day, the more likely that queues will form and the longer they are likely to grow.

Queue lengths and waiting times were observed on Saturday, September 3 and Sunday, September 4, 2005. As a frame of reference, 3,599 and 3,948 vehicles were processed, respectively, at the South Entrance Station on these two days. The Saturday volume of 3,599 vehicles would place that day as the 74th highest volume day during the preceding 12 months (shown in Figure 5). The Sunday volume of 3,948 would place it as the 24th highest volume day during the preceding 12 months.

Data collection to determine waiting times was accomplished through the use of two Personal Digital Assistants (PDAs). One observer was stationed at an upstream location (such as near the beginning of the queue) and a second observer was stationed at a downstream location (such as at the entrance station). As a vehicle passed an observer location, the last three characters of the license plate number was entered into the PDA. The observed time of the vehicle passage was also noted in the PDA using an automated feature of the PDA’s time clock (the time clocks in the two PDA’s were synchronized).

After field data collection, license plate matching was performed between the two data sets and elapsed time between the upstream and downstream locations was determined for each vehicle that had a license plate match.

The first data collection for waiting times was conducted on Saturday, September 3 from approximately 1:35 to 3:00 p.m. One observer recorded license plates as vehicles arrived at the entrance station in both the Express Lane and Lane A. The second observer attempted to stay with the end of the queue. However, this proved to be somewhat challenging because the vehicle arrival rate varied from minute to minute and the queue would grow and shrink. In other words the location of the end of the queue moved up and down the length of the roadway.

During the first data collection the length of the queue varied from a point near the south driveway entrance to the former Moqui Lodge, to the vicinity of the parking lot for the Grand Canyon entrance sign.

This data collection effort was still worthwhile because it revealed a difference in the length of the waiting time for the express lane versus Lane A. On the average, the Express Lane provided a time savings of 8 minutes, 9 seconds. The magnitude of the time savings varied from about five minutes to about 16 minutes during the period of data collection. Although it was not possible to observe the operation of the Express Lane while the data was being collected, it is possible to theorized why the time savings for the Express Lane fluctuated. At different points in time, access to the Express Lane may and may not have been blocked by the stack of vehicles backed up from Lanes A, B, and C.

In addition, at different points in time a roving VUA may or may not have directed vehicles without prepaid permits to use the Express Lane (if there was no available supply of vehicles with prepaid permits). This would have caused the Express Lane queue to “slow down” because some vehicles with longer processing times were using that lane.

The second data collection for waiting times was conducted on Sunday, September 4 from approximately 11:30 a.m. to 12:15 p.m. One observer recorded license plates as vehicles arrived at the entrance station in Lane A. The second observer was located at the beginning of the four lane section (about 380 feet upstream of the entrance station) and recorded license plates of vehicles as they entered Lane A.

This data collection effort yielded the length of the waiting time in a regular lane. The average waiting time for a sample of 32 vehicles was 14 minutes, 38 seconds. Among this sample, there was little variability in the waiting time. The shortest wait was 11 minutes, 56 seconds and the longest wait was 16 minutes, 28 seconds. Ninety percent of the observed values were between 13 minutes, 12 seconds and 16 minutes, 28 seconds.

A third data collection was also conducted on Sunday, September 4 from 12:55 to 3:00 p.m. One observer recorded license plates at the beginning of the four lane section. The second observer positioned himself at various locations upstream. Because the location of the end of the queue moved up and down the roadway, the second observer did not attempt to stay with the end of the queue. The observer did, however, collect data from 14 different locations along the roadway. The longest extent of the queue was at the Long Jim Canyon Road (1.31 miles from the entrance station). The shortest extent of the queue was at the Grand Canyon National Park boundary (0.57 miles from the entrance station and 0.06 miles north of the north entrance to the former Moqui Lodge).

As shown in Table 5, waiting times from the various locations to the beginning of the four-lane section ranged from about 15 minutes at locations near the Park Boundary and the former Moqui Lodge, to the range of 22 to 27 minutes at locations near, and south of, the “1 MILE” sign.

When the length of waiting time from the beginning of the four-lane section to the entrance station (14 minutes, 38 seconds) is added, the total waiting time to the entrance station ranged from about 30 minutes at locations near the Park Boundary and the former Moqui Lodge, to the range of 37 to 42 minutes at locations near, and south of, the “1 MILE” sign. If a vehicle used the Express Lane, its total waiting time would have been, on the average, about 8 minutes less than these values.



Queue 1.08 Miles from Entrance Station



Queue 0.8 Mile from Entrance Station



Queue 0.6 Mile From Entrance Station

TABLE 5 - WAITING TIMES

DISTANCE (MILES) FROM ENTRANCE STATION	DESCRIPTION OF LOCATION	SAMPLE SIZE	AVERAGE WAITING TIME TO BEGINNING OF 4-LANE SECTION	TOTAL WAITING TIME TO ENTRANCE STATION *
0.57	ADOT traffic counting station at GCNP boundary	3	15:14	29:52
0.63	North driveway entrance to former Moqui Lodge	4	15:50	30:28
0.63	North driveway entrance to former Moqui Lodge	3	15:16	29:54
0.66	Between north and south Moqui Lodge driveways	54	13:49	28:27
0.68	South driveway entrance to former Moqui Lodge	2	16:49	31:27
0.89	Driveway to USFS ranger station	20	23:20	37:58
1.02		41	24:46	39:24
1.08	Sign - Grand Canyon Entrance Station 1 Mile Ahead	37	27:18	41:56
1.08	Sign - Grand Canyon Entrance Station 1 Mile Ahead	41	22:04	36:42
1.20		10	24:10	38:48
1.25		3	23:54	38:32
1.29		5	25:05	39:43
1.31	100 feet north of Long Jim Canyon Road intersection	18	24:28	39:06
1.33	Long Jim Canyon Road intersection	11	26:47	41:25
*Adds the average waiting time from beginning of 4-lane section to entrance station of 14 minutes, 38 seconds				
A vehicle using the Express Lane would have had a waiting time about 8 minutes shorter than those shown				

To put these waiting times in context, two points can be made. First, the time period during which this data was collected (12:55 to 3:00 p.m.) was the time period that produced the longest lines on Sunday, September 4. In other words, this was the period of greatest “peaking” on that day (the highest volume of traffic arriving per unit of time). Second, the daily volume of 3,948 would have placed it as the 24th highest volume day during the preceding year. Thus, other days of the year with higher daily volumes would likely have produced an even longer queue, and longer waiting times, if the amount of “peaking” was the same on those days. In comparison, the highest volume day in a one year period had 4,775 vehicles pass through the entrance station during its hours of operation. This number is 21 percent higher than the volume on September 4th. Thus, it is not surprising that some very high volume days have reported queues extending to the community of Tusayan (1.7 miles from the entrance station).

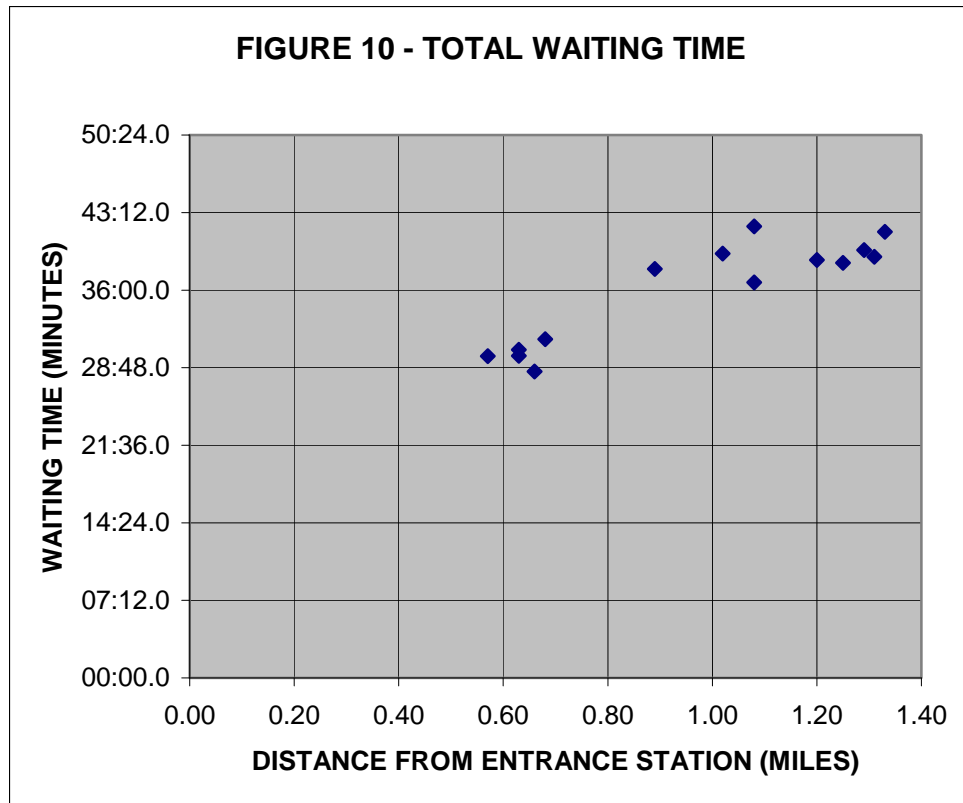


Figure 10 plots the data from Table 5 (total waiting time versus distance from the entrance station). Park staff reported their previous observation that when the line extends to the “1 MILE” sign, the waiting time is about 40 minutes. The data collected on September 4 corroborates that observation.

At greater distances from the entrance station, the data is more scattered. In other words, the distance is a less reliable predictor of the waiting time. The queue has a “slinky effect” that becomes more pronounced at greater distances from the entrance station. Some portions of the queue have longer gaps between vehicles and some portions have shorter gaps. Longer gaps tend to exist near the end of the queue where vehicles have just arrived at the end of the line. Thus, from any given location, the number of vehicles between that location and the entrance station will vary depending on whether the location is, or is not, near the end of the queue and the amount of the “slinky effect” within the length of the queue.

Based on field observations, when the queue is one mile long, there are about 212 vehicles waiting. This is comprised of 72 vehicles “stacked” in the four lane section of roadway, followed by about 140 vehicles in the single lane section of roadway.

In Grand Canyon National Park’s Report to Congress on Transit Alternatives (Ref. 6), the statement is made that “it has been assumed that the perception of crowding – particularly vehicle crowding – at Grand Canyon has contributed to the recent lack of growth in visitation....visitation to Grand Canyon National Park took a big jump between 1984 and 1993

but has been relatively flat since.” The report quotes several travel guidebooks that described high levels of visitor crowding.

The hypothesis is that information about crowding reaches potential visitors via travel guidebooks, media reports, and word-of-mouth and that potential visitors choose not to visit the Grand Canyon because of their perceptions about crowding and congestion. If this phenomena indeed occurs, the experience of 30 to 40 minute waiting times to enter the Park is a likely contributor. A reduction in waiting times during peak periods would be a substantial improvement to the visitor experience.

TIME PERIODS WHEN DEMAND EXCEEDS CAPACITY

A preceding section on Capacity of South Entrance Station concluded that the capacity is in the range of about 353 to 368 vehicles per hour. What are the time periods during the year when the demand (the number of vehicles arriving per hour) exceeds the capacity (the number of vehicles that can be processed per hour)?

The traffic volume data (described in the section on When Do High Volume Hours Occur?) was reviewed (hour by hour) to identify the hours when the entrance station was likely operating at capacity. Because the traffic volume counts are at a location downstream from the entrance station, those volumes were “metered”, i.e., constrained, by the capacity of the entrance station. Thus, there were no hours for which the observed traffic volume was substantially higher than the entrance station capacity.

Table 6 presents the results of this analysis for the month of July, 2005 (identical analysis was done for the months of April through September). The shaded cells represent the days and hours on which the entrance station was likely operating at capacity. For example, on Sunday, July 3, the entrance station was likely operating at capacity continuously from 9:00 a.m. to 5:00 p.m. Every day of the month had at least two hours operating at capacity and a majority of the days had at least four hours operating at capacity.

From April 8 through September 30 there were 176 days of traffic volume data available. The number of hours on each day when the entrance station was operating at capacity was determined. Sunday, May 28 had the most hours operating at capacity – 10 hours.

The 176 days were sorted by the number of transactions occurring on each day as shown in Table 7. After sorting by number of transactions, and then noting the number of hours operating at capacity on each day, the following observation was made. When the number of daily transactions is less than 2900, there were rarely any hours during the day operating at capacity. When the number of daily transactions is greater than 3000, almost every day has at least one hour operating at capacity. The conclusion is that 2900 to 3000 daily transactions is the “trigger point” at which waiting times and long lines begin to appear during at least part of the day. It was also observed that days with 4500 or more transactions have 8 to 10 hours operating at capacity.

TABLE 6 - HOURS IN JULY WHEN DEMAND EXCEEDS CAPACITY											
DATE	HOUR BEGINNING AT										
	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00	6:00
1											
2											
3											
4											
5											
6											
7											
8											
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Using the value of 2900 transactions as the “trigger point”, the dates before April 8 and after September 30 were reviewed to identify additional days of the year that likely experienced demand greater than capacity. Looking at a full year, it is estimated that 157 days experience at least one hour when demand exceeds capacity and that there are 515 hours per year during which demand exceeds capacity.

This report makes no attempt to quantify the vehicle-hours of delay, vehicle emissions, or wasted fuel associated with the 515 hours per year when queues exist. The magnitude of each of these impacts is substantial.

TABLE 7 - NUMBER OF HOURS WHEN DEMAND > CAPACITY

DATE	TOTAL TRANS-ACTIONS	NUMBER OF HOURS	DATE	TOTAL TRANS-ACTIONS	NUMBER OF HOURS	DATE	TOTAL TRANS-ACTIONS	NUMBER OF HOURS	DATE	TOTAL TRANS-ACTIONS	NUMBER OF HOURS
07/03/05	4775	8	07/31/05	3707	5	06/03/05	3433	1	09/20/05	2924	
05/29/05	4657	9	07/05/05	3703	4	05/20/05	3425		08/22/05	2897	
05/28/05	4645	10	07/19/05	3703	4	06/09/05	3395	3	05/18/05	2886	3
07/02/05	4519	8	07/28/05	3694	5	06/07/05	3363	2	04/29/05	2856	
07/30/05	4299	6	05/14/05	3693	4	06/05/05	3362	1	04/08/05	2849	
08/06/05	4206	8	05/21/05	3693	4	05/19/05	3346	2	04/15/05	2848	
08/03/05	4109	6	06/23/05	3692	3	05/23/05	3342	2	09/28/05	2843	
07/16/05	4090	7	06/24/05	3669	3	08/04/05	3338	5	05/01/05	2841	
05/27/05	4084	6	07/08/05	3665	2	04/20/05	3335	3	05/02/05	2812	
06/25/05	4072	6	08/14/05	3665	4	05/16/05	3296	2	08/24/05	2793	
07/13/05	4047	6	08/17/05	3665	3	05/15/05	3295	3	05/09/05	2789	
07/14/05	4022	3	06/29/05	3661	4	04/21/05	3289	1	05/05/05	2788	
06/18/05	4018	6	06/16/05	3657	4	08/19/05	3279	1	04/28/05	2784	
07/06/05	3963	7	06/15/05	3656	1	05/07/05	3267	2	04/11/05	2774	
07/23/05	3962	5	06/08/05	3648	3	05/11/05	3260	2	05/10/05	2769	
06/22/05	3958	6	06/26/05	3645	4	05/22/05	3252	2	04/24/05	2767	
08/13/05	3952	6	05/26/05	3642	1	04/16/05	3249	3	09/08/05	2761	
07/12/05	3950	5	07/29/05	3615	2	04/23/05	3234	2	05/03/05	2740	
09/04/05	3948	7	07/01/05	3611	3	04/26/05	3193	1	09/05/05	2739	
08/07/05	3934	3	09/03/05	3599	7	06/02/05	3158	1	9/26/2005	2727	1
07/26/05	3928	4	06/30/05	3595	3	04/30/05	3157	1	04/10/05	2725	1
07/15/05	3912	3	07/18/05	3583	3	06/20/05	3151	5	08/23/05	2723	
08/10/05	3906	4	08/18/05	3580	4	04/18/05	3148	2	09/12/05	2715	
08/02/05	3901	6	05/25/05	3575	2	04/19/05	3139	2	09/30/05	2672	
08/01/05	3896	5	06/27/05	3566	4	9/21/2005	3121		08/25/05	2659	
07/21/05	3895	5	06/04/05	3565	5	09/14/05	3109	1	04/12/05	2633	1
07/20/05	3888	2	06/12/05	3551	3	04/17/05	3102	2	9/11/2005	2628	
08/05/05	3881	6	06/11/05	3545	6	07/27/05	3066	5	09/09/05	2622	
07/10/05	3866	3	05/24/05	3544	2	04/22/05	3064		09/17/05	2612	1
08/09/05	3860	5	06/14/05	3532	3	04/27/05	3024	1	08/26/05	2606	
07/24/05	3844	4	05/17/05	3512	2	09/15/05	3020	2	09/07/05	2574	
07/07/05	3833	5	06/01/05	3512	2	09/25/05	3019		09/02/05	2466	
08/08/05	3822	5	05/12/05	3510		08/21/05	3012		09/27/05	2421	
07/09/05	3820	6	06/06/05	3503	2	04/25/05	3010		05/04/05	2401	
05/30/05	3798	4	09/24/05	3500		09/22/05	3005		9/6/2005	2334	
08/11/05	3788	3	06/13/05	3495	4	05/08/05	3003	1	08/28/05	2329	
07/22/05	3782	3	07/04/05	3485	2	9/16/2005	2996		04/09/05	2277	
07/25/05	3774	5	06/10/05	3477	3	09/13/05	2982	1	08/30/05	2191	
07/17/05	3748	4	05/31/05	3476	4	05/06/05	2976		08/31/05	2164	
08/12/05	3739	4	06/19/05	3476	2	09/19/05	2966	1	09/29/05	2125	
07/11/05	3735	2	05/13/05	3468	1	08/27/05	2954	1	08/29/05	2062	
06/17/05	3733	3	08/15/05	3451	3	04/13/05	2952		9/1/2005	2043	
06/28/05	3732	3	08/20/05	3442	4	09/10/05	2943	1	09/23/05	1499	1
06/21/05	3729	5	08/16/05	3435	3	09/18/05	2928		04/14/05	1343	

EXISTING STRATEGIES TO FACILITATE TRANSACTIONS

Several strategies are already in use at the South Entrance Station to facilitate transactions.

Roving VUA's

When lines become long, a Visitor Use Assistant (VUA) will often “rove” the line. One task is to help direct visitors to the proper lane for their type of transaction. As noted above, a second task is to provide a supply of non-eligible vehicles to the Express Lane if there are no eligible vehicles to use that lane. The VUA can also answer questions for visitors, thus reducing the time needed for conversation between the visitor and the VUA in the entrance station booth.

“Off-line approvals” for credit cards

In July, 2005 the South Entrance Station discontinued “on-line approvals” for credit cards. “On-line approvals” required that a phone line connection be made for a computer system to check the validity and creditworthiness of a swiped credit card. This process consumes time, especially if credit card transactions are taking place in multiple lanes at the same time.

Anecdotally reported observations by fee collection staff indicate that the change to “off-line approvals” substantially reduced transaction times for credit card transactions. Although no before-and-after quantitative data are available for the South Entrance Station, it is possible to compare the transaction times for credit card purchases at Arches (which uses “on-line approvals” and for which transaction time data was collected in March, 2005) with those at the South Entrance Station. At the South Entrance, the interval between arrivals is 9 seconds shorter for National Park Pass purchases and 53 seconds shorter for purchase of a Seven-Day Re-entry permit (see Table 2). This data strongly supports the anecdotal reports of shorter transaction times for “off-line approvals”. The fee collection staff report that the Park is experiencing a “loss rate” of only 0.7 percent by not validating credit on-line.

Suspend Photo ID Checks

The usual practice at Grand Canyon National Park is to check photo ID for those visitors who present a previously purchased National Parks Pass, National Parks Pass with Golden Eagle Hologram, Golden Age Passport, or Grand Canyon National Park Annual Pass; or a previously acquired Golden Access Passport. This is to verify that the individual presenting the pass is the person to whom it was issued and that there is no fraudulent use. This practice does reduce fraud. On September 3 the author observed a visitor who attempted to gain entry with the Golden Age Passport of a deceased individual.

Photo ID checks do consume a some time in these transactions. When lines become long the fee collection supervisor will make a decision to suspend photo ID checks and give

this instruction to the VUA staff. This is usually done when the queue backs up as far as the single lane approach.

Sale of Entry Permits at Remote Locations

Grand Canyon National Park sells passes and entry permits at three off-site locations. One site is at the IMAX Theatre in Tusayan, 2 miles south of the entrance. During 2005 the Park's intent was to staff this location with one Park Service employee from 8:00 a.m. to 6:00 p.m. each day from March to September. Staff shortages resulted in sporadic staffing. Beginning in March of 2006 this site will be staffed year-round by the Park Service. This staffed site sells all of the same types of entry permits that are available at the entrance station, including Commercial permits.

A second staffed site is at the Williams Visitor Center, 51 miles south of the entrance. Only the National Parks Pass, Golden Eagle Hologram, and Golden Age Passports are sold at this location. Three NPS seasonal employees staff this location from April through October during normal business hours. For the remainder of the year, this location is staffed by non-NPS personnel.

In addition, the Park has automated fee machines that sell Seven-Day Re-Entry permits and Individual permits. The machines are located at the Tusayan and Williams locations and also at Valle, Arizona (24 miles south of the entrance).



Purchasing a pass or an entry permits has a longer transaction time than does a simple entry on a pass or permit that has already been purchased. The greater **Automated Fee Machine** the number of purchase transactions that can be made before arrival at the entrance station, the lower the average service time and the greater the capacity.

Sale of entry permits at remote locations does improve operation at the South Entrance Station. The numbers of permits and passes sold at remote locations, however, is relatively small. Sales at the remote locations account for only about six percent of the dollar value of entry permits used at the South Entrance Station (see Table 8). This is a strategy that can be more fully exploited.

TABLE 8 - CASH RECEIPTS AT REMOTE LOCATIONS

October, 2004 - September, 2005

	IMAX Theatre staffed sales	Williams Visitor Center staffed sales	IMAX Theatre Vending Machine	Valle Vending Machine	Williams Visitor Center Vending Machine	Total at Remote Sites	South Entrance Station Sales	Combined Total	Percent Sold at Remote Locations
SEVEN DAY RE-ENTRY, INDIVIDUAL, and TRANSIT PAY *	\$186,388	X	\$118,044	\$100,255	**	\$404,687	\$6,393,082	\$6,797,769	6.0%
National Parks Pass	\$91,370	\$36,900	X	X	X	\$128,270	\$1,579,835	\$1,708,105	7.5%
GOLDEN AGE PASS	\$16,691	\$14,570	X	X	X	\$31,261	\$298,097	\$329,358	9.5%
HOLOGRAM and GRCA PARK PASS	\$405	\$165	X	X	X	\$570	\$28,210	\$28,780	2.0%
COMMERCIAL PAY and SHUTTLE PAY *	\$242,748	X	X	X	X	\$242,748	\$4,466,049	\$4,708,797	5.2%
TOTAL	\$537,602	\$51,635	\$118,044	\$100,255	\$0	\$807,536	\$12,765,273	\$13,572,809	5.9%

* In this Table, "Shuttle Pay" and "Transit Pay" refer to numbers of paying passengers. These categories are different than "Shuttle" and "Transit" used in Tables 2 and 3, which refer to the number of vehicles entering at the entrance station.

** Data unavailable at time of report publication.

Data is for October, 2004 through September, 2005

Express Lane

The Express Lane provides expedited service for selected types of transactions. It may be used by any vehicle that has a prepaid permit or is otherwise not required to pay a fee for entry to the Park. These vehicles include holders of: a previously purchased National Parks Pass, National Parks Pass with Golden Eagle Hologram, Golden Age Passport, Grand Canyon National Park Annual Pass, or Seven-Day Entry Permit; a previously acquired Golden Access Passport; Park residents or employees; or Park business-related vehicles. During a one-year period, 52.7 percent of the vehicles processed at the South Entrance station were in these eligible categories. It should be pointed out, however, that this percentage has a natural variation from day to day and hour to hour, depending on the mix of transactions.

As noted earlier in this report, the eligible types of transactions have short intervals between arrivals. As a result, the theoretical capacity of the Express Lane is high - 164 vehicles per hour. This theoretical capacity is often not achieved, even when there are long queues approaching the entrance station, for two reasons.

First, occasionally, non-eligible vehicles choose to use the Express Lane. These non-eligible vehicles have transaction times that are longer. Use by these vehicles may cause the express lane to bog down.

Second, the queue of stacked vehicles in the other three lanes often extends far enough to block access to the express lane. The result is no supply of vehicles for the express lane and inefficient "dead time" for that lane.

Third, non-eligible vehicles may be directed to the Express Lane during busy periods by a Visitor Use Assistant (VUA) that is "roving" the lines of waiting vehicles. If there are

no eligible vehicles to use the Express Lane, non-eligible vehicles will be directed there to take advantage of unused capacity.

The main advantage of the Express Lane is that it reduces the waiting time for those who are eligible to use it. If the queues are long enough to fill the three regular lanes (about 18 vehicles waiting in each lane), the time saved by use of the Express Lane was observed to be in the range of 5 to 16 minutes, with an average of about 8 minutes.

The main operational problem with the Express Lane, as it is currently configured, is that when the queue is long, eligible users are stuck in a long single lane queue for extended periods of time before they have access to the Express Lane. When the queue is one mile in length, eligible users have a waiting time of about 25 minutes before they have access to the Express Lane.

STRATEGIES USED BY OTHER PARKS TO FACILITATE TRANSACTIONS

Sale of Entry Permits at Remote Locations

Acadia National Park sells very large numbers of passes and entry permits at variety of locations outside of the Park entrance. The National Park Pass, Golden Age Passport, Golden Access Passport, Acadia National Park Annual Pass, and Seven-Day Entry Permits are sold by NPS staff at the Park visitor center (located about seven miles before arriving at the entrance station), the Thompson Island visitor information center and Chamber of Commerce (located about 14 miles before arriving at the entrance station), two NPS campgrounds (located before arriving at the entrance station), and at the transportation hub in Bar Harbor that serves the Acadia transit system. Seven-Day Entry Permits and the Acadia Annual Pass are also sold by three non-Park entities: the Northeast Harbor Chamber of Commerce, the Appalachian Mountain Club, and the Acadia Corporation (the Park's concessionaire). These three entities sell the permits and pass at face value and provide this service at no cost to the Park.

Automated Lanes

An automated system to process selected vehicles holds the promise of reducing congestion and waiting times, reducing personnel costs, and providing expedited entry for certain users.



Zion Entrance Station – Red SUV in lane)



Automated Lane at Zion (right hand

Automated Lane (right hand lane)

At least four Parks have implemented automated lanes for vehicle entry at entrance stations.

Eligible users gain entry by use of a transponder (an electronic tag) or swiping a magnetically encoded card through a card reader. Two other technologies, although not currently in use at other Parks, are proximity cards and bar code readers.

Additional information on automated lanes is presented in Appendix A.

POTENTIAL STRATEGIES TO FACILITATE TRANSACTIONS

A large variety of strategies could be pursued to reduce overall transaction times, queue lengths, and waiting times. These strategies vary in cost, time required for implementation, and practicality.

Greater Promotion of Entry Permit Sales at Remote Locations

Grand Canyon National Park currently sells entry permits at three remote locations – in Tusayan, Valle, and Williams. At present, however, these permits sales account for a very small proportion of all permits and passes sold.

A review of Table 2 shows the benefit of encouraging purchase of a permit or pass at a remote site.

- Purchase of a Seven-Day Re-Entry permit at the entrance station consumes 41 seconds (cash) or 58 seconds (credit card). Re-entering on a Seven-Day Re-Entry permit takes only 15 seconds. Purchasing at a remote location reduces the time by 26 to 43 seconds.

- The interval between arrivals for purchase of a National Parks Pass is 2 minutes, 2 seconds (cash) or 1 minute, 45 seconds (credit card). If the National Parks Pass were purchased at a remote location, the interval between arrivals for entry to the Park is only 31 seconds. Thus, the processing time can be reduced by as much as one and one-half minutes if the Pass is acquired before arriving at the Park.
- Cash purchase of a Golden Age Passport is a 1 minute, 40 second transaction at the Entrance Station. Re-entry on a Golden Age Passport is a 33 second transaction. Purchasing at a remote location reduces the time by 1 minute, 7 seconds.

Any actions that encourage a shift from purchasing at the entrance station, to purchasing at a remote location will increase the number of vehicles that can be processed in a one hour period. Purchase of a Seven-Day Re-Entry permit can be used as an example. Earlier in this report it was noted that on Saturday, September 3 (a high volume day on a holiday weekend) 50.0 percent of the vehicles were purchasing a Seven-Day Re-Entry permit. With the mix of transaction types on that day the capacity was 86 vehicles per hour per lane.

If some of those Seven-Day Re-Entry permits had been purchased before arrival at the Park, what effect would it have on capacity?

- If one-tenth of these vehicles purchased a Seven-Day Re-Entry permit before arrival at the Park, capacity would increase to 89 vehicles per hour per lane. This represents an increase of 12 vehicles per hour for four lanes.
- If one-fourth of these vehicles purchased a Seven-Day Re-Entry permit before arrival at the Park, capacity would increase to 94 vehicles per hour per lane. This represents an increase of 32 vehicles per hour for four lanes. Put in perspective, this would increase the entrance station capacity by about 10 percent.

The same type of effect can be achieved for the National Parks Pass and the Golden Age Passport. While the proportion of vehicles purchasing these passes is much smaller, the time savings on each transaction is larger.

- If one-fourth of the purchasers of Seven-Day Re-Entry permits, National Parks Passes, and Golden Age Passports made their purchase before arrival at the Park, capacity for the September 3 scenario would increase to 98 vehicles per hour per lane, representing a 14 percent increase in entrance station capacity.

What marketing methods can be used to promote increased purchases of permits and passes at remote locations? The Park webpage, media releases, Highway Advisory Radio, tourist guides, and tourist newspapers are all possibilities and will be described further in the following pages. A possible media release is presented in Appendix B.

Passenger Counts

Currently, VUA's note the number of passengers in each vehicle and enter this information as part of the transaction. When the number of passengers in a vehicle is not apparent to the VUA, the VUA will ask how many people are in the vehicle. Noting the number of persons per vehicle probably adds a few seconds to the average transaction time.

Grand Canyon began passenger counts as part of a Persons per Vehicle study. The purpose of the study was to determine if the persons per vehicle factors being used to calculate recreational visits for Grand Canyon were appropriate. The Persons per Vehicle study has now been completed.

The current passenger counts are not being used to calculate the number of recreational visits to Grand Canyon National Park. Further, the manager of the NPS public use statistics indicates that his preference is to use traffic volume counts, rather than actual passenger counts, for the recreational visits formula.

It is recommended that passenger counts be discontinued unless they serve some other useful purpose. This will reduce average transaction times by a few seconds. If the average transaction time is reduced from 39 seconds to 36 seconds, capacity will increase from 92 vehicles per hour per lane to 100 vehicles per hour per lane.

Dissemination of Pre-Trip Planning Information

One of the functions at an entrance station is to provide information on the Park (Park newspaper, souvenir map) and answer visitor questions. The more information that visitors are able to acquire before their trip, the fewer questions they will pose at the entrance station and the shorter the service time.

Visitors acquire information from many different sources: travel guidebooks, travel sections of newspapers, National Park websites, tourist newspapers picked up en-route, and other sources. The Park can be proactive in providing information to all of these sources, but the Park has the greatest influence on its own Park webpages.

A summer, 2003 visitor survey at Arches National Park found that 31 percent of Park visitors obtained information from either the National Park Service website or the Arches National Park website prior to their visit. A similar figure likely applies to Grand Canyon visitors and today, in 2005, the percentage is probably higher.

Grand Canyon National Park currently has a comprehensive set of web pages that provide a multitude of information (the home page is illustrated in Figure 11). In addition, it provides hot links to additional sites that would be useful for pre-trip planning. These links include the Grand Canyon, Williams, and Flagstaff Chambers of Commerce, and the Arizona Office of Tourism.

Among the additional information that could be provided on the Grand Canyon website is text similar to the proposed media release for pre-purchase of entry permits (Appendix

B). This text could be added to the **Plan Your Visit** page and would promote purchase of permits at remote locations.

The Park's webpages can also be useful in helping prospective visitors be better informed about their choices for fee payment. It is suggested that the Park's webpages on fees can be arranged and organized in a more effective manner.

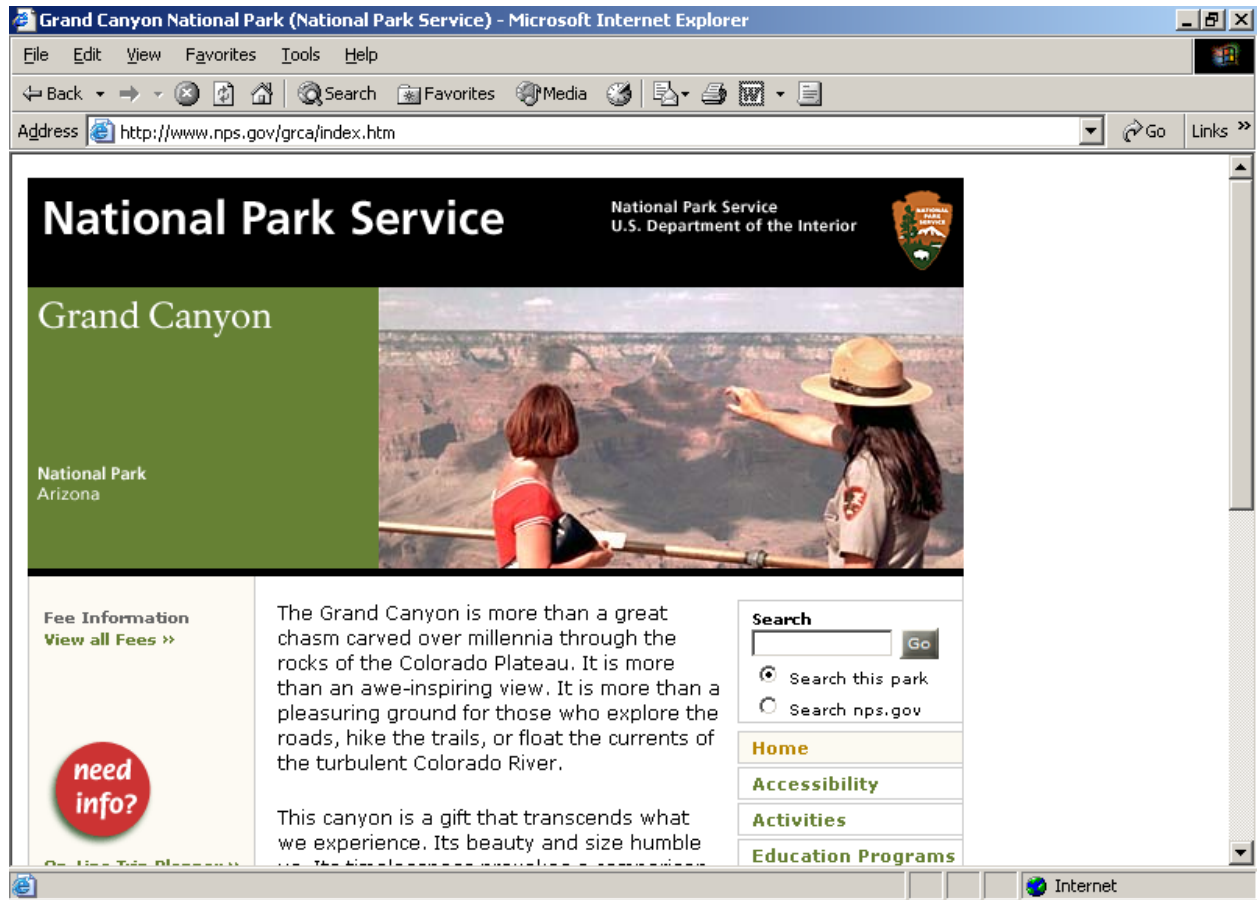


Figure 11 – Grand Canyon National Park home page

Highway Advisory Radio

Two Highway Advisory Radio systems (also known as Traveler Information Systems) currently exist. One Highway Advisory Radio transmitter is located at the entrance station. It is used to provide visitors with information about fees. It is a low power system and has an effective range of only about one-quarter mile. Park staff report that they are unable to increase the power of this system to extend the range due to concerns by the Federal Aviation Administration about interference with radio communications with aircraft. A script for the current message broadcast by this system is unavailable. Two signs on the approach to the entrance station advise visitors to tune in to the Highway Advisory Radio message.

A second Highway Advisory Radio transmitter is located within the Park. The broadcast becomes audible about one mile north of the entrance station and this system is used to provide motorists with general Park information.

There is only one sign presenting information about fees. It is located immediately in front of the entrance station between lanes A and B. The sign is not visible to those approaching the entrance station in the other lanes. Many visitors arrive at the entrance station unsure about their choices for fee payment. This uncertainty leads to one or more questions, followed by decision-making about what type of pass or permit to purchase. If visitors were better informed about their choices, questions about fee payment would be reduced and more visitors would make their decision about what type of pass or permit to purchase prior to arrival at the entrance station.

An earlier subsection of this report described the benefits of pre-purchase of passes and entry permits before entering the Park. Highway Advisory Radio could also be used to encourage pre-purchases.

Additional locations for Highway Advisory Radio systems could be located in Williams, just south of Valle, and between Valle and Tusayan. These locations could promote the remote purchase sites in those three communities. A possible script is presented in Appendix D.

Appendix E presents a proposed script for the Highway Advisory Radio located at the entrance station. Any location at which Highway Advisory Radio is used needs to have highly visible roadside signing to inform the traveler of its availability.

Reliability of Fee Collection Software System

System failures and crashes occur periodically in the fee collection software system. Several crashes were observed during nine hours of data collection on September 3, 4 and 5. When a crash occurs the VUA usually must reboot the computer. This causes an interruption in the processing of vehicles and a reduction in capacity. One system crash was observed that resulting in a service time of 5 minutes, 32 seconds for a cash purchase of a Seven-Day Re-Entry permit.

If downtime due to system failures and crashes and rebooting could be reduced, capacity could be improved.

Increase Number of Lanes

The most assured way to increase capacity and reduce queue lengths and waiting times is to increase the number of lanes at the entrance station. This is a high cost solution that would require a long time to implement (planning, environmental compliance, design, and construction).

How many additional lanes would be needed to offer short waiting times during peak periods? Preferably, good traffic volume data on the *approach* to the entrance station would be available to answer this question. Unfortunately, that data does not exist.

Ideally, traffic volume counts, by 15 minute intervals for an entire summer season would be very helpful in answering this question. And, these counts would need to be made at a location upstream from the end of the queue. Such counts would allow an analysis of the peaking of traffic volumes *arriving* at the entrance station. (See further discussion in subsection on Recommendation for Traffic Count Station)

Because detailed upstream traffic volume count data is not currently available, a different analytical approach must be used to answer the question of how many additional lanes would be needed. Currently, demand begins to exceed capacity at a “trigger point” of about 3000 vehicles per day. If one additional lane (a 25 percent increase in capacity) were added, the trigger point would also increase by 25 percent to a value of about 3750 vehicles per day. There are 38 days per year that have more than 3750 transactions. Therefore, one additional lane would still leave 38 days with a queueing and waiting time problem.

If two additional lanes (a 50 percent increase in capacity) were added, the trigger point would increase to a value of about 4500 vehicles per day. There are only four days per year with greater than 4500 transactions. Two additional lanes would relieve almost all of the delay problem, provided that Park visitation does not increase and the current level of traffic volumes does not change. The bottom line is that one additional lane would still not provide an acceptable level of service for about 38 days per year; two additional lanes would provide an acceptable level of service on almost all days of the year

Additional discussion on this topic is included in the section on Entrance Station Improvements in the Context of the Transportation Plan.

Promote Use of Desert View as Entry Point to Park

While the South Entrance Station often has long queues and waiting times, the Desert View entrance station has excess capacity. There are four entry lanes at the South Entrance Station and two lanes at Desert View. Although Desert View has only half as many entrance lanes, only about one-fourth as many vehicles enter the Park at Desert View (see the second section of this report, on Existing Conditions).

Promoting the use of Desert View as an entry point is a form of “transportation demand management”. For visitors from selected points of origination, entry at Desert View offers an alternative that may meet their needs. Consider two examples.

1. Although no statistics are available to the author, it is reasonable to assume that a significant proportion of South Rim visitors originate in the Phoenix urban area. Phoenix is both a large urban area (in excess of 3 million population) and the location of a major airport serving tourist travelers.

Most travelers from Phoenix to the South Rim will drive Interstate 17 to Flagstaff. From that point they have three choices for approaching the South Rim. They can travel west on I-40 to Williams and then travel north on State Route 64. They can take U.S. Route 180 to Valle and then north on State Route 64 to Tusayan (the shortest distance between

Flagstaff and “the heart of the Canyon”). Or, they can travel north on U.S. 89 to Cameron and then west on State Route 64 to the Park. The mileages from the I-17 / I-40 interchange in Flagstaff to Mather Point via these three routes are 86, 81, and 107 miles respectively.

Some of these visitors simply drive directly to the “heart of the Canyon” via one of the first two routes, spend time in the South Rim Village area, and then leave the Park by driving south on State Route 64. Others take the opportunity to include the East Rim Drive as part of their visit and make a “loop” from Flagstaff in either a clockwise (Flagstaff to Valle, through the South Entrance Station to South Rim, to Cameron to Flagstaff) or counterclockwise (Flagstaff to Cameron, through the Desert View Entrance Station, to South Rim to Valle to Flagstaff) direction.

If informed of the possibility of long waiting times to enter the Park, some of these visitors would choose to enter at Desert View rather than the South Entrance. And, some of these visitors would choose to make a “loop” in the counterclockwise direction rather than the clockwise direction. Such diversions would relieve pressure on the South Entrance Station.

A media release in the Phoenix market provides an opportunity for a well-targeted message to a target market. Such a release could advise of the potential for long waiting times and suggest entry at Desert View as an alternative. A possible media release is presented in Appendix C.

2.A similar situation exists for westbound cross-country travelers on Interstate 40. They also have three choices for approaching the South Rim. They can exit I-40 at Williams and travel north on State Route 64 (the shortest distance between I-40 and any point on the South Rim). They can exit I-40 at Flagstaff and take U.S. Route 180 to Valle and then north on State Route 64 to Tusayan (the shortest distance between Flagstaff and “the heart of the Canyon”). Or, they can exit I-40 at Flagstaff, travel north on U.S. 89 to Cameron and then west on State Route 64 to the Park. The mileages from I-40 Exit 201 (the U.S. 89 exit) in Flagstaff to Mather Point via these three routes are 92, 87, and 101 miles respectively.

Those travelers who are intent on just a “quick look” at the Canyon probably choose one of the first two approaches. If informed of the possibility of long waiting times to enter the Park, some of these visitors would choose to enter at Desert View rather than the South Entrance. This target market would be most easily reached via information provided at rest areas on westbound I-40.

At first glance, diversion of visitor entries to the Desert View entrance could be perceived as a disadvantage to the Tusayan business community. Two arguments can be made, however, that this strategy works to the benefit of Tusayan. Visitors who consume 30 to 40 minutes of time waiting in line at the South Entrance will have less time remaining at the end of their day to spend shopping, eating at restaurants, and visiting other Tusayan business establishments. On a long term basis, reductions in congestion and crowding

will benefit Tusayan. Many believe, as noted earlier in this report, that high levels of congestion deters visitation to the Park. If congestion is reduced, higher levels of visitation may ensue.

Before implementing promotion of Desert View as an entry point, close consultation with the Tusayan business community is highly recommended.

If, through this strategy, 10 percent of the current entries at the South Entrance Station could be diverted to the Desert View Entrance Station, queue lengths and waiting times could be significantly reduced.

Promote Ridership on Grand Canyon Railway

Currently, the Grand Canyon Railway accounts for about 6.6 percent of the combined total of visitors arriving by vehicle through the South Entrance and by the Grand Canyon Railway. During the peak months of June, July and August, the Grand Canyon Railway accounts for 5.2 percent to 6.8 percent of the combined total of visitors.

Promoting ridership on the Grand Canyon Railway – to the extent that it diverts trips from motor vehicle to rail, rather than simply generating new trips by rail – could reduce the demand at the South Entrance Station. Given that the Grand Canyon Railway currently accounts for only a small percentage of South Rim visitor arrivals, a large increase in railway ridership would be required to make meaningful reductions in demand at the entrance station.

Because the railway is a private business, Park Service policies may limit the Park's ability to promote the Grand Canyon Railway.

Improve information on eligible users of the Express Lane

Not all eligible users understand that they may use the Express Lane. Additional steps can be taken to improve this information.

The existing signing (Sign 1, and Sign 3, which is identical) lists most (but not all) of the classes of vehicles that may use the “express lane”. Golden Eagle, Golden Age, Golden Access, Re-Entry, Annual Pass, and Park Residents are specifically identified. One sizeable class of eligible vehicle that is not specifically identified is National Parks Pass. Although “Annual Pass” may be intended to cover the National Parks Pass, there is probably uncertainty by holders of the



Sign 1

National Parks Pass on whether they may use the express lane. “Annual Pass” may also be intended to cover the Grand Canyon National Park Annual Pass. Again, there is probably ambiguity in this message and uncertainty whether the Park Annual Pass is eligible for the express lane. The number of Grand Canyon National Park Annual Passes

in circulation is so small (only 246 sold in a 12 month period), that its listing on the sign is not justified.

Those who qualify for Re-Entry Business are not listed on the sign. This, however, is a difficult class to describe simply on a sign. This group, because they are repeat entrants to the Park, probably know that they are eligible for the express lane.

“Re-Entry” is probably intended to mean re-entry by those who hold a Seven-Day Re-Entry permit. The meaning of “Re-entry”, however, may not be clearly recognized by those with Seven-Day Re-Entry permits. It is suggested that this wording be identical to wording that appears on the receipt / entry permit (see additional discussion below).

The author has 25 years of experience specializing in traffic control devices and extensive background in human factors as applied to sign design. Based on that experience, the author recommends a change in the wording and layout for this sign panel. While the differences from the existing sign design may appear subtle, the author believes they will result in higher driver comprehension. The suggested layout is shown below.

Left Lane	
Prepaid Permits Only	
7 Day Re-entry Permit	Golden Access
National Parks Pass	Golden Eagle
Golden Age	Park Residents

This places the order of appearance of five of the six classes in descending order of use, making it more likely that the driver will find the class that applies to him. The one exception is Park Residents, who can be presumed will quickly learn that they are eligible.

The lower sign panel, that reads: “Commercial Vehicles Right Lane Only” is probably interpreted by some drivers to mean that only commercial vehicles may use the right lane. Observations of driver behavior at the entrance station support this hypothesis. It is recommended that the wording be changed to read as follows.

Commercial Vehicles Must Use Right Lane

Improved information on eligible users of the Express Lane can also extend to the printed permits. The printed permit / receipt given to the purchaser of a Seven-Day Re-Entry permit at the entrance station could include the following printed message.

IF YOU RE-ENTER THE PARK,
USE THE PREPAID PERMITS LANE

Similarly, Seven-Day Re-Entry permits sold at remote locations (either by vending machine or by staff) could include the following printed message.

USE THE PREPAID PERMITS LANE
TO ENTER THE PARK

And, when staff at a remote location sell any of the passes (Seven-Day Re-Entry permit, National Parks Pass, Golden Age Passport, etc.), the staff can tell the purchaser they are authorized to use the Express Lane.

Messages similar to this could also be broadcast on Highway Advisory Radio.

Automated Lanes

Automated Lanes have several advantages. They can serve very effectively for certain classes of users, such as Park residents, Park employees, official vehicles, and Re-Entry Business – users that do not require interaction with a Visitor Use Assistant. At the South Entrance Station these classes of users account for 20.38 percent of the vehicles entering the Park on an annual basis. A major advantage in serving these users with an automated lane is a savings in personnel costs.

There are three reasons that an automated lane may not be practical at the South Entrance Station.

First, no good data currently exist on the service times for automated entry. Service times for Re-Entry Local and Re-Entry Business users are only 3 seconds under existing manual operation. It is unlikely that there would be any capacity-enhancing benefit from an automated lane.

Second, a lane would need to be dedicated for this purpose. Taking an existing lane for automated use would be counterproductive in terms of overall entrance station capacity because it would not be fully utilized (there are not enough eligible users to provide a supply of vehicles 100 percent of the time). The alternative of constructing an additional

lane for automated use is an option that involves cost and time for implementation. Those classes of users who would be eligible for an automated lane would want continued easy access (as they do now for the Express Lane). Accomplishing this goal would likely require significant roadway construction.

Third, dissemination of electronic tags or magnetic stripe cards to eligible users would be an administrative issue.

Lengthen Express Lane

The effectiveness of the existing Express Lane in reducing waiting times is often hindered by the long queues. If the queue is 1 mile long, those eligible to use the Express Lane will be waiting about 25 minutes before they have access to the Express Lane. If the Express Lane were extended to allow eligible users to truly bypass a long queue, the eligible users would have much shorter waiting times. Because it is reported that it is common for queue lengths in the summer to reach 1 mile or more, it would be desirable to extend the Express Lane to 1 mile in advance of the entrance station to allow bypass in most situations. It is important to point out that while a 1 mile long express lane would greatly reduce waiting times for eligible users and would also reduce the length of the queue, it would not increase the entrance station capacity and it would not reduce the waiting time for users of the regular lanes.

A one mile long express lane would also require very careful consideration of traffic operations and highway safety issues. There are three locations within one mile of the entrance station at which vehicles enter and leave the highway: the parking lot at the Grand Canyon entrance sign, the driveways at the former Moqui Lodge, and the Kaibab National Forest Tusayan Ranger Station. Higher speed travel in an express lane, adjacent to a slow moving regular lane, creates sight distance problems for vehicles crossing these lanes when entering or leaving the roadway. A possible solution is to place a bypass lane on a separate alignment on the east side of the existing roadway. It could begin just north of the Tusayan Ranger Station, pass to the east of the entrance sign parking area, and rejoin the existing roadway at the entrance station.

This is also a high cost solution that would require a long time to implement (planning, environmental compliance, design, and construction). A one mile long express lane would extend outside of the Park. Planning, design and construction would require coordination with the Arizona Department of Transportation and Kaibab National Forest.

Summary of Potential Strategies and Recommended Strategies

Table 9 summarizes potential strategies to facilitate transactions. The strategies are grouped into four categories. Strategies to Reduce Transaction Time will cut the time to process each vehicle. Strategies to Increase Supply accomplish this either through reduced downtime or an increase in physical facilities. Strategies to Reduce Demand attempt to shift the demand to other locations to access the Park.

Within each category, existing strategies that would be continued are generally listed first. The remaining strategies are then generally listed in order of increasing time to implement and increasing cost. If a strategy will increase capacity, a note describes the potential to do so.

This table can serve as a discussion tool for Park decision-makers.

A very pertinent question to ask is: “If implemented, how will the Park know if a strategy is having an intended effect? For some of the strategies there is no practical way to know for sure that a strategy is producing a benefit. Suggested tests for selected strategies include the following.

Greater Promotion of Entry Permit Sales at Remote Locations: The proportion of sales occurring at remote sites can be monitored.

Promote Use of Desert View as an Entry Point: The proportion of South Rim entry transactions occurring at the South Entrance versus Desert View can be monitored.

Promote Ridership on Grand Canyon Railway: Grand Canyon Railway Ridership, in proportion to South Entrance Station entries, can be monitored.

TABLE 9 - SUMMARY OF POTENTIAL STRATEGIES					
STRATEGY	STATUS	COMMENTS	TIME TO IMPLEMENT	COST	INCREASE IN CAPACITY
STRATEGIES TO REDUCE TRANSACTION TIME					
Roving Visitor Use Assistants	Existing + Continue	Ensures there is no unused capacity in express lane			
"Off-line approvals" for credit cards	Existing + Continue	Reduces transaction time			
Suspend Photo ID checks	Existing + Continue	Reduces transaction time			
Sale of Entry Permits at Remote Locations	Existing + Continue	Reduces average transaction time			
Greater Promotion of Entry Permit Sales at Remote Locations	Proposed	Reduces average transaction time	Short	Very Low	Up to 14 percent if one-fourth of certain permits are purchased in advance
Discontinue Passenger Counts	Proposed	Reduces average transaction time	Immediate	None	8 percent
Dissemination of Pre-Trip Planning Information	Proposed	Better informed visitors will ask fewer questions.	Short	Low to Very Low	
Highway Advisory Radio	Proposed	New locations can promote purchase of permits at remote sites. New and existing locations can provide information about fees. This will lead to fewer questions by visitors.	1 year for new locations	Low	
STRATEGIES TO INCREASE SUPPLY					
Reduce System Failures and Crashes	Proposed	Reduces downtime	Short	Unknown	Perhaps a few percent
Increase number of lanes	Proposed		3 - 5 years	Very High	25 percent for 1 lane, 50 percent for 2 lanes
STRATEGIES TO REDUCE DEMAND					
Promote Use of Desert View as Entry Point to Park	Proposed		Short	Very Low	Possibly 10 percent
Promote Ridership on Grand Canyon Railway	Proposed		Short	Very Low	Possibly 1 percent
OTHER					
Express Lane	Existing + Continue				
Improve information on eligible users of Express Lane	Proposed	Improve signing	6 months	Low	
	Proposed	Print message on permit / receipt	immediate	None	
	Proposed	Print message on remote sold permits	3 - 6 months	Very Low	
	Proposed	Broadcast on Highway Advisory Radio	3 months	Very Low	
Add an Automated Lane	Proposed		2 years	Medium	~ 25 percent for 1 lane
Lengthen Express Lane	Proposed	Extend express lane to avoid queue	3 years	Very High	None, but does reduce waiting time for eligible users

RECOMMENDATION FOR TRAFFIC COUNT STATION

One of the major data gaps for entrance station planning at this location is a lack of information about the arrival pattern of vehicles at the end of the queue. In short, the degree of “peaking” that occurs in vehicle arrivals is unknown. This lack of information makes it more difficult to know the levels of hourly demand and the duration of the peak periods.

It is strongly recommended that a traffic counting station be installed so that count data will be available as entrance station planning progresses in future months and years. The counting station could be either a permanent counting station (inductive loop detector) or a temporary counting station (pneumatic hose) deployed for perhaps 100 days each summer season.

It is recommended that this counting station be located far enough upstream so that queues rarely extend as far as the counting station. A good location would be in the vicinity of Long Jim Canyon Road. The traffic counter should tabulate counts by 15 minute intervals. It would count only the northbound traffic.

This traffic count data would also be exceptionally useful for the ongoing planning activities for the Park's transportation plan. For example, the arrival rates would be very useful in determining the needed capacity and frequency for bus transit service from Long Jim Canyon into the Park.

The Park has the choice of contracting with a private sector firm that offers traffic counting services or deploying and maintaining (on a daily basis) a traffic counter using its own forces. The Park should consider the advantages and disadvantages of each approach.

[Note: The Arizona Department of Transportation has a counting station located at the Park boundary (just north of the north driveway entrance to Moqui Lodge). This location is marked by a sign on the east side of the highway that reads "ADOT TCS". ADOT has inductive loop detectors installed in the roadway at this location. ADOT collects data at this location on only a few days each year. The inductive loop detector for northbound traffic has failed. An ADOT representative reports that the loop is unlikely to be repaired before the next roadway improvement project at this location and no improvement project is scheduled within the next several years.]

DOWNSTREAM EFFECTS

The current capacity of about 368 vehicles per hour serves to meter the flow of traffic north of the entrance station. With the current four lane operation, northbound traffic volume will rarely exceed a rate of 368 vehicles per hour.

If the capacity of the entrance station is increased, will the congestion problem simply move elsewhere? For example, will congestion result at the intersection of the South Entrance Road and Center Road, or at the intersection of the South Entrance Road and the East Rim Drive? will greater congestion result at Mather Point?

A highway capacity analysis was done for the South Entrance Road / Center Road intersection (a signalized intersection). Traffic volumes for a July weekend (the highest days of the year) were assumed. This analysis showed that the traffic volumes at this intersection would have to more than double before traffic volume exceeds capacity. Thus, only a very substantial increase in entrance station capacity (more than double) would cause a congestion problem at this location.

A similar analysis was done for the South Entrance Road / East Rim Drive intersection. This intersection is not currently signalized and its traffic volumes are lower. Substantial increases in traffic volume would have to occur before signalization would be needed to

control the traffic volumes. If signalized, this intersection would have even more “excess capacity” than the Center Road intersection.

Mather Point and the adjacent Park roadway currently experience extreme parking congestion during the peak season. Vehicles parallel park along the Park roadway for an extended distance (one-fourth mile or more) from the parking lot entrances. The parallel parking, pedestrians crossing the road, and pedestrians suddenly appearing from between parked cars are safety problems. This is a location that would experience a greater peaking in vehicle arrivals if the capacity of the entrance station is increased.

ENTRANCE STATION IMPROVEMENTS IN THE CONTEXT OF THE TRANSPORTATION PLAN

Grand Canyon National Park has been working on a transportation plan for the South Rim for many years. In fact, a transit system between Tusayan and the South Rim was proposed in the Park’s 1995 General Management Plan. A major milestone in the transportation planning effort was the Report to Congress on Transit Alternatives (Ref. 6). That report presented five alternatives (referred to as Options 1 – 5) that involved mandatory visitor use of a transit system and one alternative (referred to as Option A) that included a voluntary transit system. Each of the six alternatives would utilize a transit system that would be boarded at Long Jim Canyon (north of Tusayan and south of the South Entrance Station).

Options 1 to 5 would dramatically reduce the number of vehicles passing through the South Entrance Station. If any of these five options were implemented, a four lane entrance station would have very adequate capacity for processing vehicles. However, the costs of Options 1 to 5 are extremely high. It appears that the current consensus is that the Grand Canyon will not pursue a transportation plan that requires mandatory transit use to gain access to the Park at the South Entrance.

Option A establishes a goal of achieving a voluntary 15 to 25 percent diversion to a transit system. If a 15 to 25 percent diversion were achieved, would it relieve the congestion problem at the South Entrance Station? Currently, demand begins to exceed capacity at a “trigger point” of about 3000 vehicles per day. If 25 percent of visitors are diverted to a voluntary transit system, it would be the equivalent of raising the trigger point to 4000 vehicles per day.

There are 13 days per year that have more than 4000 transactions. Therefore, a voluntary transit system, even if successful in diverting 25 percent of visitors, would still leave 13 days with a queueing and waiting time problem. A 15 percent diversion would still leave 74 days with a queueing and waiting time problem.

Regardless of what alternative is ultimately selected for implementation (Options 1 – 5, Option A, or some other alternative), no option will likely be implemented and in operation for some number of years. In the meantime, existing entrance station

operational problems will continue to exist if strategies to facilitate transactions are not pursued. For that reason, there is a compelling need for the Park to select strategies for implementation in the near future.

SHOULD ENTRANCE STATION BE STAFFED FOR MORE HOURS PER DAY?

Park staff have considered the possibility of opening the entrance station earlier in the day and closing it later in the evening. They have even considered the possibility of 24 hour operation. A review of traffic count data provides information on the numbers of vehicles entering the Park before the entrance station opens and after the entrance station closes. As examples, on an average July day 59 vehicles entered the Park between 4:00 and 5:00 a.m. and 69 vehicles entered the Park between 9:00 p.m. and 10:00 p.m.

What the traffic volume counts do not show is the number of these vehicles that would be subject to fee collection. If Park staff want to further explore the possibility of longer hours, it is recommended that a survey be conducted of vehicles entering the Park earlier and later in the day to determine the number of vehicles subject to fee collection. The Park can then determine whether of costs of fee collection would make longer hours economically worthwhile.

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NATIONAL PARK TRANSPORTATION SCHOLAR PROGRAM

This program is sponsored by the National Park Foundation. Each year, Parks compete for the opportunity to be assigned a Transportation Scholar to assist the Park with its transportation problems and issues. Individuals also compete for the opportunity to serve as a Transportation Scholar. Parks and individuals are selected for the program and the best matches between an individual's skills and experience and a Park's needs lead to the assignment of individuals to Parks. For additional information about the program, contact the National Park Foundation.

AUTHOR CONTACT INFORMATION

Jonathan Upchurch, P.E., P.T.O.E., Ph.D.
National Park Transportation Scholar
P.O. Box 1849
Grand Canyon National Park, AZ 86023-1849
Phone: 928-638-7694
E-mail: Jonathan_Upchurch@partner.nps.gov